metals and alloys

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HIGHLIGHTS

Written by the Abstract Section Editors and the Editorial Staff

DO YOU want to know what metallurgical engineers are saying, the world over? Look in the Current Metallurgical Abstracts. Here are some of the points covered by authors whose articles are abstracted in this issue.

"Demagnetization in a Magnetic Field"

Davis (page MA 349 L 8) says that demagnetization in a magnetic field makes possible the concentration of iron ores that cannot otherwise be handled. We don't understand the mechanism of it, but the results sound interesting.—H.W.G.

Something Odd About Abnormal Steels

According to Sawamura (page MA 358 L 8) abnormal carburizing steel is not abnormal if gas carburized instead of box carburized, which sounds odd.—H.W.G.

An 8-Ton High Frequency Furnace

Leonhardt tells of a German high-frequency furnace of 8 tons capacity (page MA 359 L 2).—H.W.G.

Stress-Relief of Fusion-Welded Pressure Vessels

Dr. Jacobus (page MA 362 R 5) emphasizes that so many features of stress-relief have not been settled, some concerns still employ it on all pressure vessels after welding, in order to assure maximum safety and reliability. The ASME Code allows certain exemptions. However, we have a lot to learn on the subject of stress-relief and, while we should be looking forward to the possibility of using more liberal rules, we should make sure not to proceed unless reliable scientific data and facts show that the revised rules will be safe.—E.V.D.

Polishing Soft Metals

The preparation of aluminum and light alloys in general for microscopic examination is a matter of very considerable difficulty except to the expert in these metals. The ordinary metal microscopist will welcome the information given in the two abstracts on this subject (page MA 365 L 5 and page MA 365 L 6).—H.S.R.

Is Hydrogen Necessary for Chromium Plating?

Recent study of the deposition of chromium suggests that the hydrogen which is evolved so vigorously plays an important role in the process (page MA 365 L 7). Instead of being an unavoidable nuisance, it is stated to be necessary in the final reduction of the chromium to the metallic state. The theory developed may have possible application in the deposition from aqueous solution of other more active metals.—H.S.R.

A New Test for Welds

By zigzagging a device that looks like a soldering copper over the surface of a weld or a rolled plate, it is possible to locate slag inclusions and other defects (page MA 366 R 4).—C.S.B.

Measuring the Temperature of Aluminum Blocks

If you jab at an aluminum block with the proper kind of a pitchfork, you can tell the temperature of the block (page MA 366 R 5). Just make the pitchfork with one prong of Cr and one of Ni-Cr and connect them to a galvanometer.—C.S.B.

A Trick Borrowed from the Medicos

A common method used by doctors to locate "internal defects" in patients is to feed them barium sulphate and then look at them with an X-ray fluoroscope. The same idea is now suggested for magnesium castings—except that "forced feeding" must be resorted to (page MA 366 R 6). The heavy material lodged in the pores makes them more easily seen than when empty.—C.S.B.

Modulus and X-Ray Diffraction

A modulus of 1, mentioned in the article by Clark and Beckwith (page MA 366 R 7), sounds rather peculiar until one realizes that it has to do with X-ray diffraction, not elasticity.—H.W.G.

"Amorphous Cement" Disinterred

Beilby's ghost must rock with raucous laughter, for Rupp (page MA 370 L 2) is able to interpret his electron-diffraction data only to mean that polishing changes the surface of a metal to a semi-liquid state. Further, by condensing metallic vapors on polished surfaces, it was proved that the surface material behaves as an undercooled liquid. Beilby's ideas seemingly will not sleep in peace.—J.S.M.

More Advice for the Polisher of Cast Iron

Those persons interested in polishing cast iron, without knocking out most of the graphite, can read how it is done (page MA 370 L 5). Those already able to do the trick will find an illuminating comparison of methods. The paper should not be read by those who send out their specimens if very, very complacent about it.—J.S.M.

Something About Zirconium Wire

Burgers and Jacobs (page MA 370 L 6) discuss the properties of drawn zirconium wire. Wonder how many people have had pure wrought zirconium to work with.—H.W.G.

More About the "Undissolved Kish" Theory

Piwowarsky again points out that the solubility of graphite in molten iron is so rapid that the "undissolved kish" theory of the superheating of cast iron is bunk (page MA 370 L 6). Wonder how long it will take before the metallurgists, who glibly cite this theory, will wake up to the fact that it probably is far from the truth.—H.W.G.

The Nitric Acid Test for Stainless Steel

Miller (page MA 374 R 3) gives useful pointers on the nitric acid test for stainless steel. If the sample won't quite meet the weight loss requirement, try other lots of acid until you find one with a sufficient inhibiting impurity to make it pass, since different lots of acid may cause the results to vary 45 per cent. Now what the heck does a test mean that can't be specified better than that, and what has such a test to do with service against anything but nitric acid?—H.W.G.

War Declared on White Ants

Who would have imagined that white ants would cause corrosion! And yet Griffiths (page MA 374 R 6) tells us that white ants deposit formic acid when they take a walk on a telephone cable and the formic acid corrodes the cable sheath. Why not train the ants to take a walk somewhere else?—V.V.K.

Windmills

The more we can put Nature to work, the less we have to work. Why not make the windmill protect our pipe lines from soil corrosion? Neil Williams (page MA 374 R 8) says it works.—V.V.K.

Is Scrap Aluminum Cable Valueless?

Callies thinks that scrap aluminum cable is practically valueless, (page MA 374 R 9). This doesn't sound reasonable to us.—H.W.G.

The Wear of Cast Iron

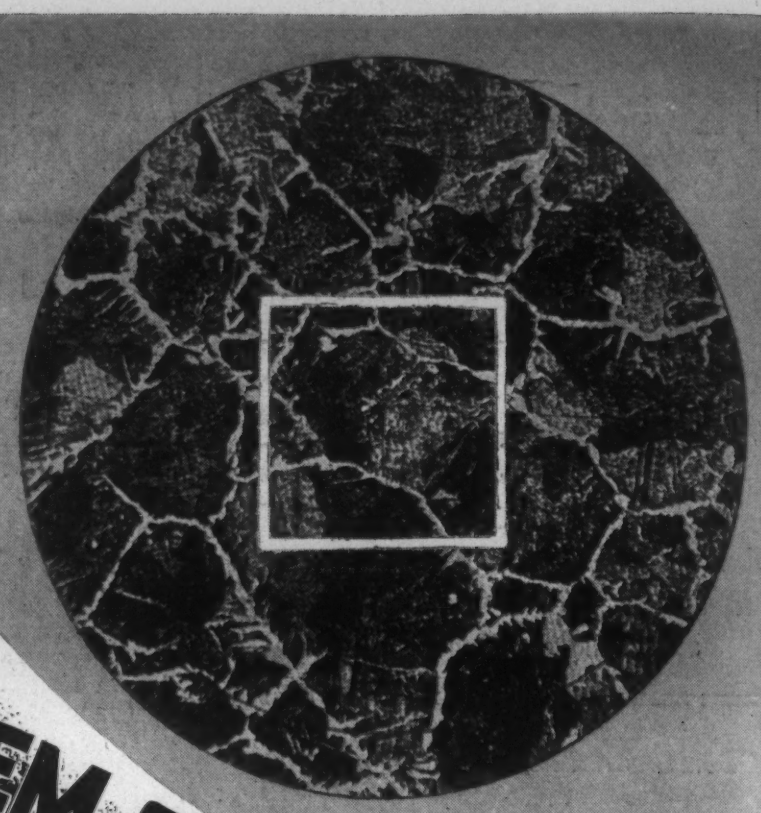
Sipp (page MA 375 L 1) discusses at length the wear of cast iron. While the influence of some factors can be appraised, on the whole he thinks nobody knows a whole lot about the subject.—H.W.G.

Oxygen vs. Carbon Dioxide

A tremendous amount of work has been done on the effect of oxygen on corrosion. Very little work has been done on the effect of carbon dioxide, particularly when both are present. Finnegan, Corey and Jacobus (page MA 375 L 3) find that one part per million of dissolved oxygen is approximately as corrosive as 20 parts per million of dissolved carbon dioxide. Their paper is well worth study.—V.V.K.

Overcoats for Turbines

Rubber overcoats for turbines to prevent erosion from cavitation are suggested by Burn (page MA 375 L 4) and for underground pipe lines by Bredburg (page MA 374 R 10). For the latter purpose Bredburg, in another article (page MA 365 R 7) mentions celluloid. Cellophane has still to be suggested.—H.W.G.



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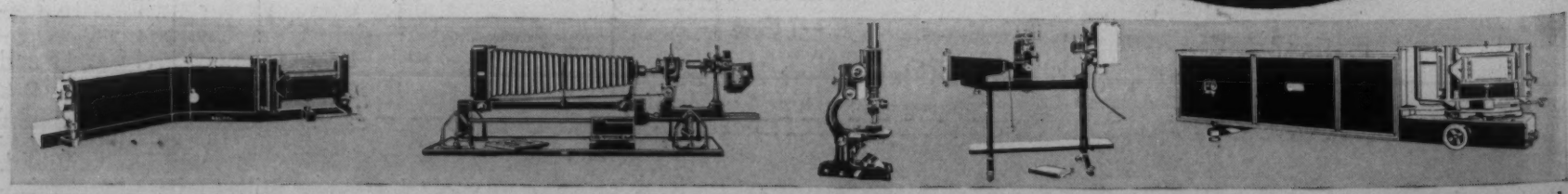


Medium Spectrograph, Large Metallographic Equipment, FSM Microscope, SI Metallographic Equipment, Littrow Spectrograph

The Editorial Advisory Board

(Continued from the July and August Issues)

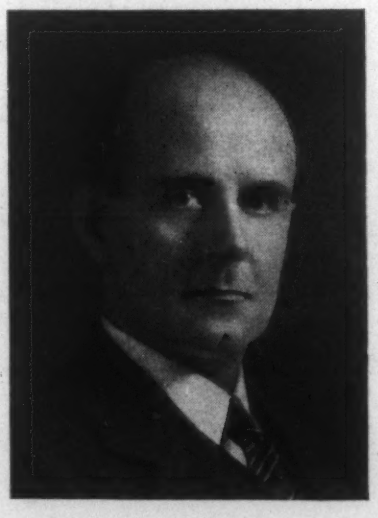
JUNIUS D. EDWARDS is assistant director of research, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa. He was graduated from the University of Minnesota in 1912 with the degree of B.S., and in 1913 he obtained his degree of chemical engineer. The next six years were devoted to research in the physical chemistry of gases at the Bureau of Standards. At the close of the war, he joined Dr. Francis G. Frary, then organizing the research laboratory of the Aluminum company. In this way he became interested in the physical chemistry and metallurgy of aluminum.

Among the subjects in which Mr. Edwards has been particularly interested are: The production of pure aluminum (99.99% Al) by electrolytic refining and the determination of its fundamental properties; the modification of Al-Si alloys with metallic sodium and the mechanism of this action; the oxide coating and coloring of aluminum; the development of aluminum paint from a little-used novelty coating to an important commercial product, extensively used in painting both metal and wood. His book, "Aluminum Bronze Powder and Aluminum Paint" and various technical papers summarize the development of this art. The book, "The Aluminum Industry," in two volumes, represents a number of years of literary and editorial effort on the part of Mr. Edwards and his confreres.

He has occupied his present position since 1921.

J. D. EDWARDS

O. W. ELLIS is director of metallurgical research of the Ontario Research Foundation, Toronto, Canada. Born in England, his early education was obtained at the Leys School in Cambridge. He left this school to serve an apprenticeship at locomotive engineering from 1905 to 1910 with the Great Western Railway Co. After spending the year 1910 in Canada with the Canadian Pacific Railway Co., he returned to England and was graduated from the University of Birmingham in 1914. From 1914 to 1921 he occupied various positions in the Royal Ordnance plants at Woolwich, England, and became chief metallurgist of the Royal Laboratory Department in 1915. He resigned from this position in 1921 to become assistant professor of metallurgical engineering at the University of Toronto.



O. W. ELLIS

During 1925 to 1929 Mr. Ellis was in Pittsburgh, for one year with the Mellon Institute of Industrial Research and for two and one-half years with the Westinghouse Electric & Mfg. Co. in its research department. In 1929 he returned to Toronto to the position which he now holds.

In 1922 Mr. Ellis was awarded a Carnegie Scholarship by the Iron and Steel Institute (British). He also received one of the W. H. McFadden prizes from the American Foundrymen's Association for a paper he presented at the 1928 convention of the association.

H. J. FRENCH is in charge of alloy steel and iron development in the research and development department of the International Nickel Co., New York. He was graduated in 1915 in metallurgical engineering from the School of Mines, Columbia University. His early industrial experience includes non-ferrous chemical and assay work for the American Smelting & Refining Co. at Murray, Utah, in 1915; as metallurgical engineer, from 1916 to 1917, in charge of laboratories and heat treatment departments of the General Vehicle Co., Long Island City, N. Y.; and in 1917 to 1919, inspector, and later chief tubing inspector, for the metallurgical sections of the U. S. Bureau of Aircraft Production.

From 1919 to 1929 Mr. French was engaged in metallurgical research work, portions of it in close cooperation with industry, at the National Bureau of Standards, Washington. At first he was in charge of the heat treatment section; later, assistant chief, division of metallurgy—for five years in close association with G. K. Burgess and H. W. Gillett. He came to the Nickel company in 1929 and was for two years in the research laboratory at Bayonne, N. J., in charge of alloy steel and iron research. In 1931 he assumed his present position.

H. J. FRENCH

Mr. French has published more than 50 technical papers since 1919, including a book on "Quenching of Steels." He was awarded the Howe gold medal in 1931 by the A. S. M. and was the Campbell Lecturer in 1933.

(Left)

Discharge end of furnace showing conveyor on automatic quench tank.

(Below)

Charge end of furnace, showing Controlled Atmosphere Preparation Unit at right.

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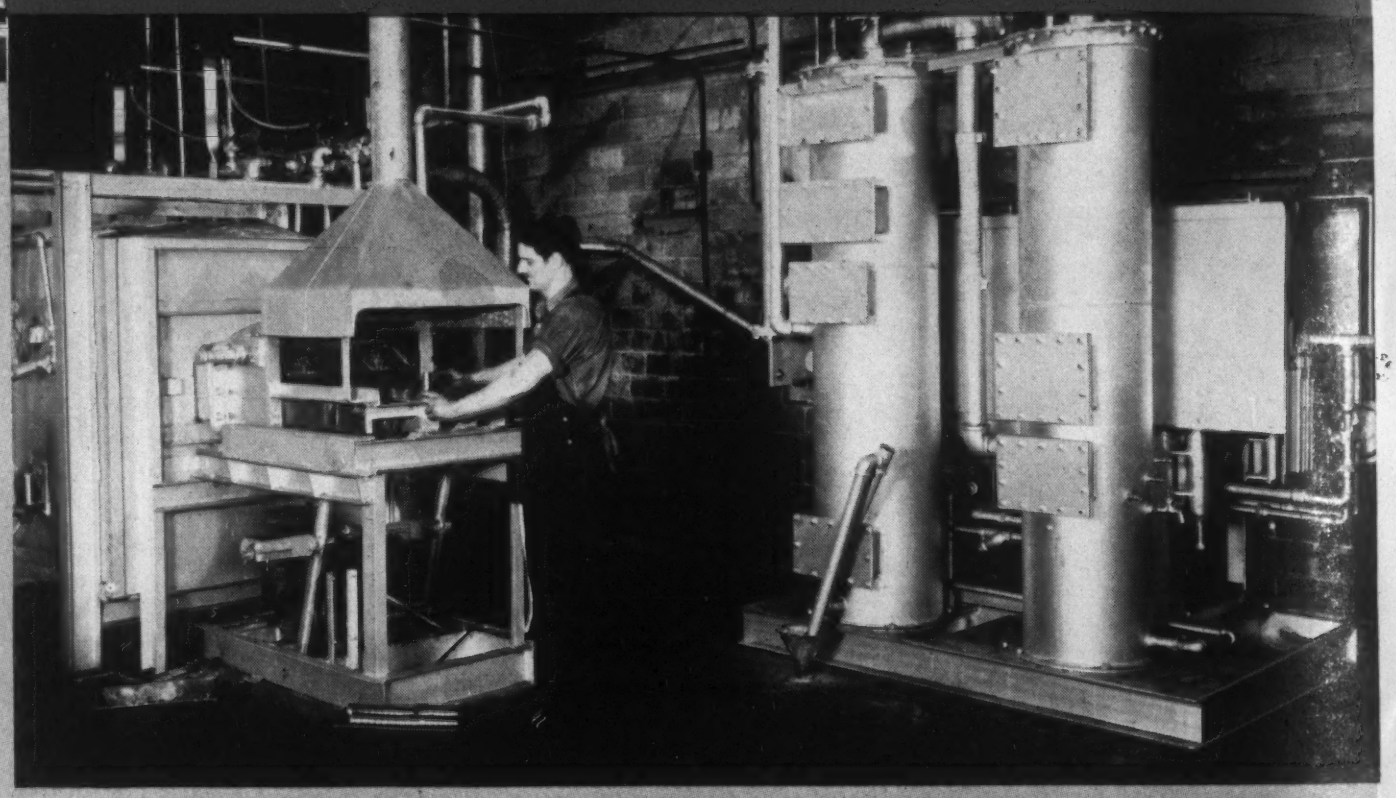

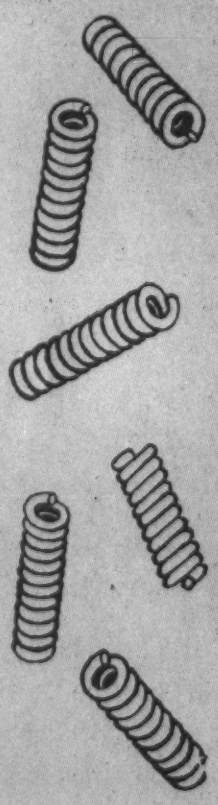

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EDITORIAL COMMENT

The Spectrograph in the Metal Industry

THAT the spectrograph is rapidly assuming a vital and important role in the chemical and metallurgical engineering laboratories was impressively demonstrated at the annual convention of the American Society for Testing Materials. Six papers, which made up a symposium on spectrographic analysis, abstracted on other pages, presented authoritatively some of the high spots in the progress in this field. It appears that in research, as well as in commercial investigations, this tool is doing yeoman work.

One of the papers dealt with steel where spectrographic analysis is being applied for the accurate determination of many of the common elements. There remains, however, further development to insure quantitative detection of phosphorous, arsenic and particularly sulphur by this method.

Commercial application in the magnesium alloy, in the cadmium and in the non-ferrous alloy industries was declared to be now decidedly successful. In magnesium alloys the quantitative routine analysis for manganese and silicon is regular laboratory practice, and it is useful in both quantitative and qualitative research regarding other elements. The presence of such impurities as copper, zinc, nickel, iron, lead and particularly thallium is detrimental to the properties of cadmium. Here the spectrograph is now an essential tool in producing commercial cadmium. It was stated that in certain non-ferrous alloys such as chromium in nickel, magnesium in zinc, aluminum in nickel and barium in nickel alloys, rapid and accurate determinations are now common practice with decided advantages over ordinary chemical methods.

In the platinum industry spectrographic methods are in daily use with many advantages. In the manufacture of graphite electrodes for use in spectro-chemical analysis the detection and the regulation of the presence of boron, silicon, aluminum, iron and several other elements in regular practice.

Already in this and other countries the installation of spectrographic equipment has made rapid strides. And many research and other institutions in the metal and alloy field are seriously considering its use or have already made plans to do so. Every indication now points to the probability that the spectrograph will become quite generally as necessary and useful as the chemical balance, the microscope and other conventional equipment.—E. F. C.

Metallurgy in the Ford Trade School

A LEAFLET describing the Henry Ford Trade School recently fell into our hands. The school annually takes some 400 boys from the Detroit district, between the ages of twelve and eighteen, for a four years' high school course, each year having thirty-four weeks of shop work, fourteen weeks of academic work and four weeks' vacation. The academic subjects cover English, Math, Mechanical Drawing, Auto Mechanics, Shop Theory, Civics, Economics, General Science, Commercial Geography, Physics, Chemistry, Qualitative and Quantitative Analysis and Heat Treatment (Metallography and Photomicrography).

Exceptional graduates of the Trade School may go into the Apprentice School in which more advanced work in Mathematics, Mechanical Drawing, Metallurgy and Metallography, Electricity and Steam Engineering is given. "It is from these trained men that the company recruits its foremen and specialty men."

The prospect that foremen in our most advanced metal-using industry, the automotive industry, will be so trained that they look upon a micrograph as they do a blue print, is a most encouraging one.

Another sentence interested us. "The floors of shops and classrooms are swept by students as a part of their training, each boy taking his turn at this necessary work."

We have an idea that the course in Economics taught by instructors with the Ford point of view would be a lot sounder than the average college course in that subject.—H. W. G.

Up and Down

THE advance information on the materials for 1936 cars indicates that the usual swinging of partners and changing all around is again in evidence with cars whose makers have decried aluminum pistons on the score of too low wear resistance now shifting to aluminum, and others that have found it necessary to use aluminum for performance shifting to cast iron, and doubtless maintaining satisfactory performance.

The merry-go-round of improved design, improved materials, and ways of producing pistons at lower cost brings a slightly different combination around each year.

A similar state of flux is observed in bearings, with regular babbitt, cadmium-base and copper-lead all in large production, but with the situation complicated by new lubricants that do not act kindly to some of the materials under hard driving conditions, and with no certainty as to which will be the future favorite. Changes in engine design that will pull operating temperatures up or down might have a large influence on the choice, and slight improvement in any of the types of alloys might swing the balance. Here again, the cost of getting a satisfactory answer by one engineering route or another is the factor that really counts.

We are generally told that the final proof of the suitability of materials for automobile construction is service in owners' hands. But surely with the hundreds of thousands of cars in which the different pistons and bearings have been used, there should be unmistakable statistical evidence by this time if any one material has a huge lead over its competitors. As long as this shifting keeps up from year to year, one must conclude that the scales are in pretty even balance.—H. W. G.

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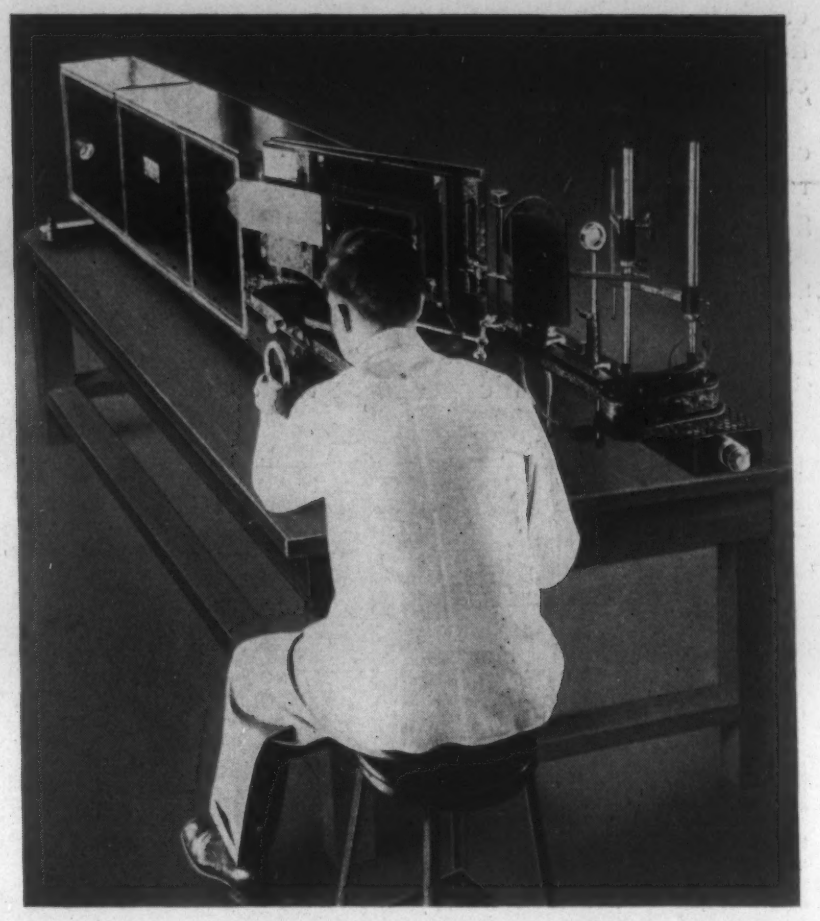
Progress in Spectrographic Analysis—I

A Correlated Abstract

By THOMAS A. WRIGHT

Secretary and Technical Director
Lucius Pitkin, Inc., New York



A Large Littrow Quartz Spectrograph Used Extensively in Routine Spectrographic Analysis. (Courtesy of Bausch & Lomb, Rochester, N. Y.)

SIX PAPERS MADE UP A SYMPOSIUM on Spectrographic Analysis at one of the sessions of the June meeting of the A.S.T.M. in Detroit. These papers have not been printed. At the request of METALS & ALLOYS, *Mr. Wright has made an abstract of these papers and other related publications, interjecting his own comments. The result is an interesting and valuable presentation of the status of this development as applied to metals and alloys. The six papers referred to are:*

"Spectrographic Analysis of Steel Samples," by Prof. W. R. Brode, Ohio State University.

"The Use of the Spectrograph in the Platinum Industry," by H. E. Stauss, Baker & Co., Newark, N. J.

"Quantitative Spectrographic Analysis of Magnesium Alloys for Manganese and Silicon," by J. S. Owens and J. M. Hess, Dow Chemical Co.

"The Spectrographic Determination of Impurities in Commercial Cadmium," by Francis W. Lamb, Bohn Aluminum & Brass Corp.

"The Purification of Graphite Electrodes for Spectrographic Analysis," by G. W. Standen and L. Kovach, Jr., New Jersey Zinc Co.

"Quantitative Analysis of Non-Ferrous Alloys by Spectrographic Methodods," by Prof. R. A. Wolfe, University of Michigan.—EDITOR.

THE CHOICE OF A quartz spectrograph, as the means of quantitatively determining minor percentages of the elements, appears with all the authors of the papers abstracted to have been for substantially the same reasons that have guided most workers in the industrial field. Stauss[1], however, in discussing the platinum industry mentions two factors not usually stressed—the value of platinum metal samples and their chemical inertness. In addition the re-use of scrap, because of the high value, is mandatory and scrap implies contamination. This vital question has been considered for another group of metals by Wright[2] from the viewpoint of the spectrograph and by Sullivan[3] from that of chemical analyses.

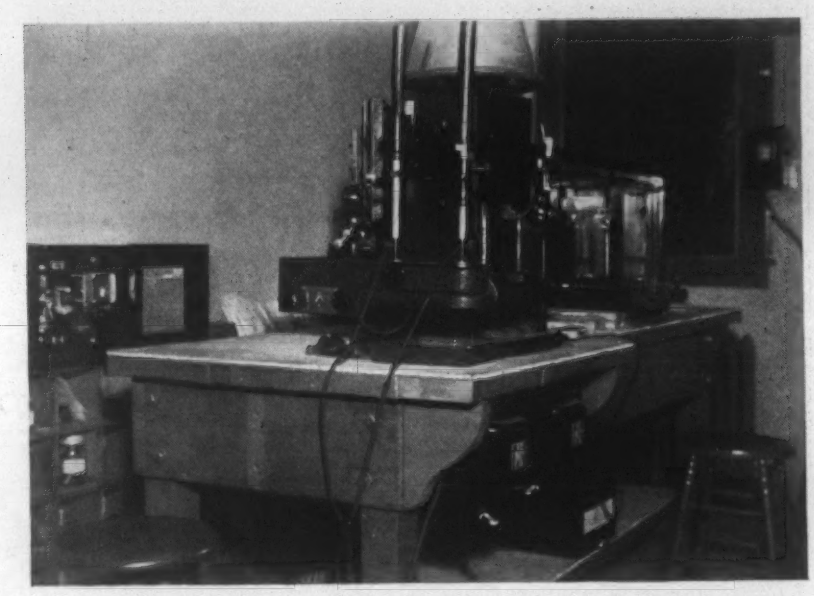
Stauss finds the greatest fields of qualitative or semi-quantitative emission spectrography to be in the identification of metals and alloys, special analyses for minor impurities and control of the process and production of high purity platinum, rhodium, etc., etc.

The author uses the term "semi-quantitative" to denote studies in which the relative amounts of the minor metals (specifically in his case the impurities or contaminants) are desired; i.e. they are given in order of occurrence or importance. The terms "quasi" or "quali-quantitative," as the abstractor prefers, imply such an application of the spectrograph and, for some types of laboratories, a very valuable and often recurring one. If an arbitrary index based on the lowest amount of any one element is set up, the progress or removal of contamination can often be followed. With experience, even fair approximations as to amounts can often be made. Stauss appears to confirm this observation, by inference at least.

The final check on such highly purified metals is perhaps more readily obtained (at times with even greater confidence) by means of physical tests for thermal e.m.f., resistance or hardness. Spectrographic analyses and some one of the methods of measurement will usually identify standard formula alloys. Contamination may be general or localized. The spectrograph is an obvious choice for stage to stage inspection as contamination occurs or comes under control. The gauze

catalyst used in ammonia oxidation is given as a particular example of the necessity for particularly close control in the later stages of fabrication.

In the author's quantitative work conducted by the comparison standard-line intensity method, a bead is formed directly by arcing the sample in the recessed graphite electrode. In fact, his standard comparison sample beads are also made directly by melting several components to form the desired alloy. Usually 50 mg. and 20 sec. exposure suffice. The amperage is not given. Future efforts are to be directed to adaptation of the logarithmic wedge sector technique.



A Spectrographic Set-Up Used Mostly in Control Work by a Large Metal Refining Co. Over 600 quantitative determinations a month are made with this apparatus. (Courtesy of the United States Metals Refining Co., Carteret, N. J.)

Commercially refined and high purity cadmium is ably discussed by Lamb[4], again with special reference to impurities. After a steady growth in production and presumably use, interrupted in 1930, cadmium in 1934 attained a production of 2,777,384 lb., an increase of 22 per cent over 1933 and practically equal to that of 1930.

Of the principal uses, including electroplating, solder and paint, the first accounted for some 65 per cent in 1934. Of this about one-third is used in the automotive industries and the balance is distributed over a variety of products ranging from caskets and burial vaults to small pins. Cadmium base-bearing alloys are one of the newer uses.

The purity of cadmium has gradually increased from the former Silesian standard of 99.50 to 99.90 per cent and in many cases to 99.99 per cent, thus matching the remarkable purity attained in the high grade special zinc for which a method was developed by the research laboratories of the New Jersey Zinc Co. This having been submitted as a contribution of Sub-committee III, although really the work of Fuller and Standen, has been accepted at the recent June meeting as the first tentative standard method of spectral analysis by the parent Committee E-2[35]. At this time no designation has been assigned.

Lamb rightfully calls attention to the difficulty of determining the minute amounts present of the common impurities zinc, lead, copper, iron, nickel, thallium and tin by routine control methods of chemical analyses. Zinc in particular offers opportunities for error as most methods are long and tedious, although a colorimetric method developed by Isbell[6] is relatively rapid. All the impurities in commercial cadmium lay within the range of spectrographic sensitivity.

Owen and Hess[7], as the result of ten years' experience in the general control of the processes of a large diversified chemical manufacturing plant, have graduated from purely qualitative work to the use of quantitative methods which in some cases have displaced chemical analyses. In developing the method described for manganese and silicon in magnesium alloys they have tried various methods of measuring line opacities including the use of the logarithmic spiral disc. They have found most success in using the Hansen step-diaphragm [8, 9, 10, 41] (which becomes effectively a stepped slit) inserted directly before the slit as opened to maximum width.

The continuous spectrum of an appropriate light source, such as the condensed spark of aluminum in hydrogen[10] is then photographed and since the widths of the steps vary logarithmically to the base 1.5, this photograph produces on the plate a pattern consisting of a series of bands of known variations of intensity. Spectra of the specimens having been placed on the same plate, the densities of a selected pair of either arc or a pair of spark lines, one of the main element (internal standard) and the other of the element desired, are measured with a Gaertner microdensitometer. The steps (2400 Å and 3800 Å) are also so measured. From the densities of the steps of the calibration pattern is obtained the density logarithm of intensity calibration curve of the plate[9],[11]. The logarithms of the relative intensities of the pairs of spectral lines are then obtained by applying their measured densities to that curve.

The procedure must be carried out for a series of alloys of known composition in which the concentration of the element under test varies over the range required for the analyses. From this data an analytical curve[12, 13, 14] relating the logarithm of the relative intensity to the percentage of the element desired, is drawn. Once drawn the curves are used for all future analyses of that specific metal or alloy. Such a curve is given for manganese and silicon in magnesium for the range 0.0 to 1.6 per cent.

Brode[30] attacks the problem of applying quantitative spectrography to the more neglected field of ferrous metals. In choosing to work on the determination of copper, nickel, tin, chromium and manganese in open-hearth steel, samples each representing a year's production of 18 different manufacturers were used. Composition, as furnished by Sullivan[5] with the samples, is given in Table I.

Table I.—Residual Metals in Open-Hearth Steels

Per Cent

Sample	Ni	Cu	Sn	Mn	Cr
1	0.115+	0.058	0.007	0.25	0.038
2	0.040	0.196	0.006	0.10+	0.029
3	0.074	0.318+	0.041+	0.13	0.036
4	0.091	0.218	0.024	0.18	0.039+
5	0.039	0.135	0.023	0.20	0.037
6	0.038+	0.083	0.006	0.22	0.020+
7	0.086	0.281	0.025	0.17	0.037
8	0.075	0.150	0.015	0.25	0.034
9	0.039	0.049+	0.005+	0.40+	0.035
10	0.044	0.075	0.010	0.27	0.030
11	0.049	0.078	0.008	0.27	0.031

Given a method permitting reproducible results for the metals mentioned, which are those of particular interest in studying pickup from the use of scrap, the spectrograph, of course, as in all such comparisons, has obvious advantages.

Brode departed from the usual methods of illumination for the line method in placing the condensing lens adjacent to the slit. As originally planned comparison was to be made of the sector method with density photometer readings. For that purpose seven exposures were made. All plates were taken on an E-316

Hilger instrument (3 meter local length) in the range 3200 to 4400 Å. A group of iron lines (assembled in tabular form for convenience by the abstractor—See Table II) was used as internal comparative standards.

Table II.—Internal Reference or Comparative Standards

In Agstrom Units—I.A.				
Selected Lines		Principal Lines		Notes
Iron	3246	Copper	3247	Approx. same intensity
	3271		3273	
Iron	3268	Tin	3262	
Iron	3415	Nickel	3414	
	3495		3492	
	3516		3515	
Iron	4245	Chromium	4254	
	4247		4274	
	4352		4289	
Iron	4009	Manganese	4030	Triplet
	4014		4033	
	4021		4034	

Except, for example, in the case of copper and tin, where the observed lines were quite different in intensity from the average iron line, and the corresponding iron lines of similar intensity were required, the mean value for the 13 iron lines was used. The determination of the log-sector values was made with the Bausch & Lomb plate reading glass with a scale divided in 0.1 mm whereby an estimate of 0.02 is possible but the error is really of the order of 0.1 to 0.2 mm.

The intensity values were obtained by means of a Bausch & Lomb comparator using a Weston photo coil and a Leeds & Northrup H. S. Galvanometer giving a total swing of 32 cm from light to dark. The ratio of deflection values gave a measure of relation line intensity. Tables for values by each method are given in the paper but the nature of the samples prevented presenting the desired proof of the precision of either method.

Brode, however, states that a series of observations made by the solution method gave a series of photographs that were quite uniform and that the intensities varied directly with relative concentration of the element. Highly satisfactory results are expected on a set of homogeneous samples to be shortly available from which a series of calibration curves will be prepared by arcing the drillings.

Examining and Measuring a Spectrum Line. (Courtesy of Bausch & Lomb, Rochester, N. Y.)

Sampling

As it stands Figs. 3 and 4 in the paper[30], giving graphical representation of the data accumulated, amply demonstrates the necessity for homogeneous samples. Brode's experience as amply demonstrates that spectroscopists are not always in a position to choose the form of the sample and that, if unhomogeneous as they often are, then a method must be used that will overcome or at least minimize the sampling error. In fact, experience in general in emission spectrography indicates that workers in the field must be prepared, as occasion requires, to use as samples solutions, powders, salts, drillings, raspings, filings, solid and/or self electrodes, castings or even a selected area as in segregation, or corrosion studies.

The influence of the analytical chemist may perhaps be responsible for the choice of solutions and comminuted samples for spectrographic work while the physicist appears to lean towards self electrodes. There is no doubt that in many cases the spectroscopist will be forced, by practical consideration of sampling and cost, to resort to spectrochemical methods or otherwise forego solid electrodes. As a matter of fact, one of the most valuable phases of Brode's[30] presentation of his work on steel samples was his emphasis on the necessity of proper drawing and conditioning of the sample. The portion used in analytical work of whatever character should represent a cross-section of the sample and the sample should represent the lot of material.

It was very evident that the discrepancies between Brode's spectral results and those obtained by chemical analysis, were due partly to the fact that the samples were made up of composited drillings representing many heats rather than drillings from a melted bar of the composite. More important still, many alloys when drilled develop a segregation into coarse and softer pieces *vs* fine and brittle, thus requiring a weighed screen separation.

As probable, there will be circumstances where line intensity measurement must be measured photometrically instead of visually and the log-sector may be superior to or more convenient than the line. Or, again, where the internal standard is not feasible, then the comparison standard or the step-diaphragm may be indicated.

Wolfe[15], to whose work and that of his associates further reference will be made, apparently has studied most of the methods devised since Lockyear[16] made the first attempts at quantitative work, but the pro-

cedures presented by him in June are specific examples of the method as given in the patent[17]. This patent incidentally contributes not only an interesting critique of the state of the art but lists a number of the salient references with which spectrographists should be familiar[16],[18] to [28] and [12].

Electrodes

Stauss[1] prefers the use of the small beads of metal, arced in graphite electrodes, because his experience too indicated that the spark was not as sensitive and standard size electrodes made of the sample are not readily available. The latter is, of course, generally true even of less costly metals although industries producing or employing a metal in the form of wire and sheet could readily employ self-electrodes where the use of a sample in the form of a solid rather than a solution is feasible. Certainly irregular or disconcerting amounts of impurities in graphite electrodes may

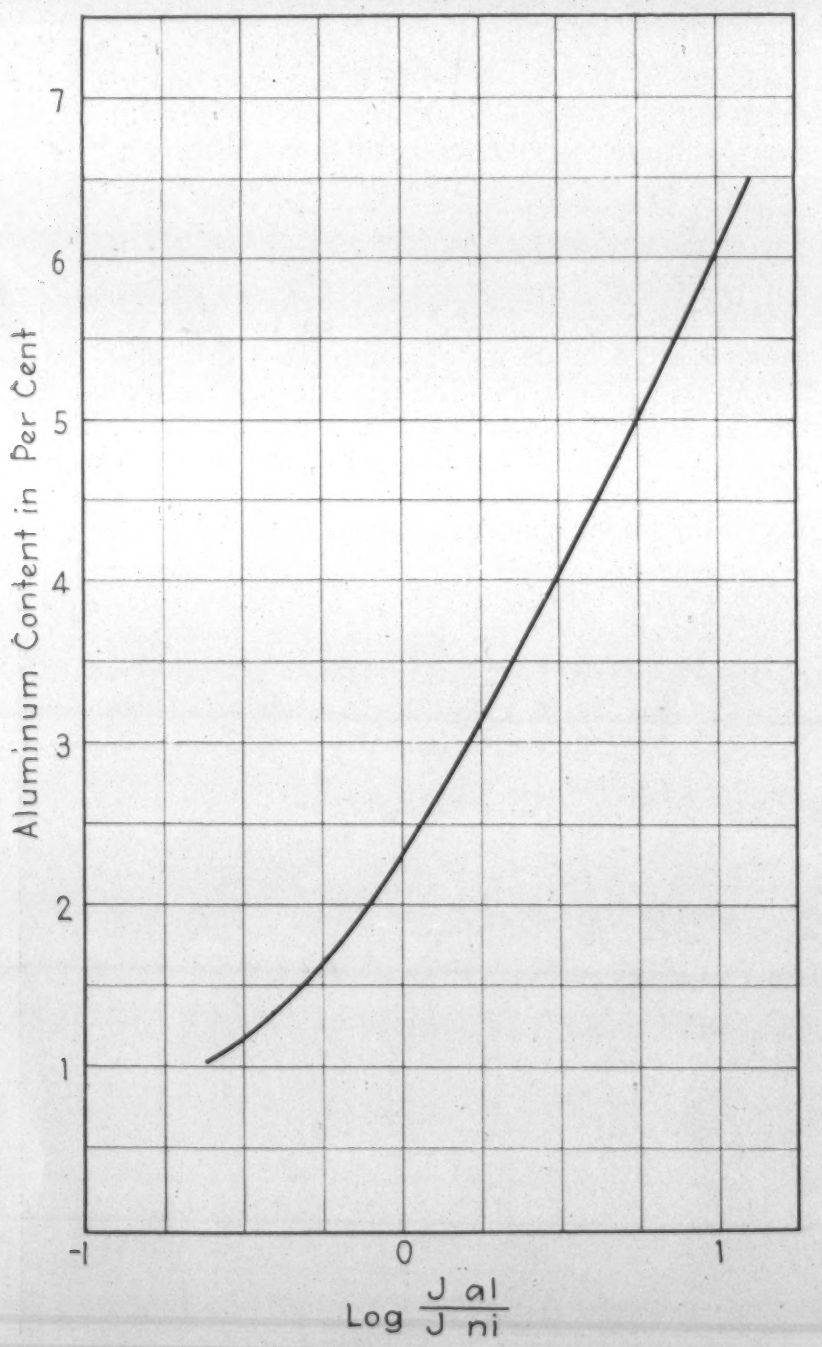


Fig. 1.—Percentages of Aluminum in Nickel (from the Wolfe paper[15]). Based on a Comparison of the Aluminum Line at 2660 A with that of Nickel at 2746 A.

seriously affect the reliability of qualitative to say nothing of quantitative spectral or spectrochemical studies.

Standen and Kovach[29] presented an interesting contribution to the art of purifying graphite which, it is hoped, will find decreasing necessity except as a method of reassurance where the integrity of high purity electrodes may be questioned. No doubt the uniformity and comparative freedom from bothersome impurities will improve as the makers develop a better technique in response to the greater and more critical use.

As it is, the two methods presented will be of interest, not only to those who, like the authors, are vitally interested in the production and control of the high purity metals, but also to those interested in corrosion, biological, animal and plant nutrition, and other fields where metallic minutiae exercise either detrimental, beneficial or catalytic effects. One of the methods relies principally on consecutively heating at 1000 deg. C. the electrodes in atmospheres of ammonia and chlorine for a total of 23 hrs. for a charge of some 600 re-graphitized electrodes of 5/16 in. dia. cut in 2 in. lengths. The specially designed furnace described is only filled to one-third of capacity and is mounted on trunnions for easy discharge and on wheels so that it may be rolled under a hood for proper disposal of the vapors.

Detailed instructions are given for the solvent purification method as well. In this procedure the cut electrodes are allowed to acid soak for at least 20 hrs. at a temperature of 70 deg. and after a preliminary boil. A 1-1 mixture or conc. HNO_3 and HCl is recommended. After washing with distilled water, a further soaking is given for 20 hrs. at 50 deg. C. in conc. NH_4OH and this in turn, after again washing in H_2O, is followed with glacial acetic acid again for 20 hrs. and at 70 deg. C. The acetic acid is washed out, another short ammonia treatment given and finally dried.

Whichever the choice of method, the usual practice of preliminary arcing to further prepare a pure area for receipt of sample must be followed. For this time consuming operation, the authors have developed, illustrate and describe an ingenious mechanism which automatically burns each of 31 electrodes for a period of about 1¾ min. at a current of 10 to 15 amp. and in the positive position.

Both methods substantially remove such impurities as magnesium, vanadium, aluminum, calcium, copper, iron, manganese and titanium, one or more of which may be normally present but leave silicon and boron. As described the furnace treatment appears to require less time and is less costly.

Lamb[4] also prefers the 5/16-in. Acheson graphite electrodes but Wolfe[15] makes no mention of the type except that in the determination of aluminum in nickel a ¼-in. dia. electrode and in that of magnesium in zinc alloys a ½-in. electrode was employed. Reference is made to the use of a series of alloys, solutions or mixtures in determining the working curves and a preference for the arc rather than the spark, but in the several examples given self electrodes were used. In the patent of Duffendack and Wolfe[17] reference is made to the use of "an arc (or spark) between electrodes consisting of or containing the material to be tested."

Owens and Hess[7] in determining manganese in the range 0.009 to 1.5 per cent and silicon 0.005 to 2.0 per cent for example in magnesium alloys substantially use the Duffendack-Wolfe technique, the merits of which unfortunately may not be properly considered due to a strong undercurrent of resentment rapidly building up because of the patent feature. These magnesium alloys contain approximately 90 per cent magnesium with varying amounts of manganese, silicon, aluminum, zinc, copper, iron, cadmium and tin either as alloying constituents or as impurities and where the spectrographic method exceeds in, or has

been developed to, a comparable precision it is used instead of chemical analyses. Solid alloy electrodes, dimensions not given, are employed but, contrary to the preference of Wolfe and many others in the United States, Owens and Hess prefer the condensed spark discharge, the mechanical and electrical conditions of which are carefully controlled in accordance with a predetermined constant condition.

Brode[30] introduces a novelty in the form of a nickel-iron cup, which will contain 5 grams of sample drillings, connected to the positive side and a graphite electrode to the negative. However, where feasible he too prefers the sample in rod form, at least for iron and steel.

Precision and Range

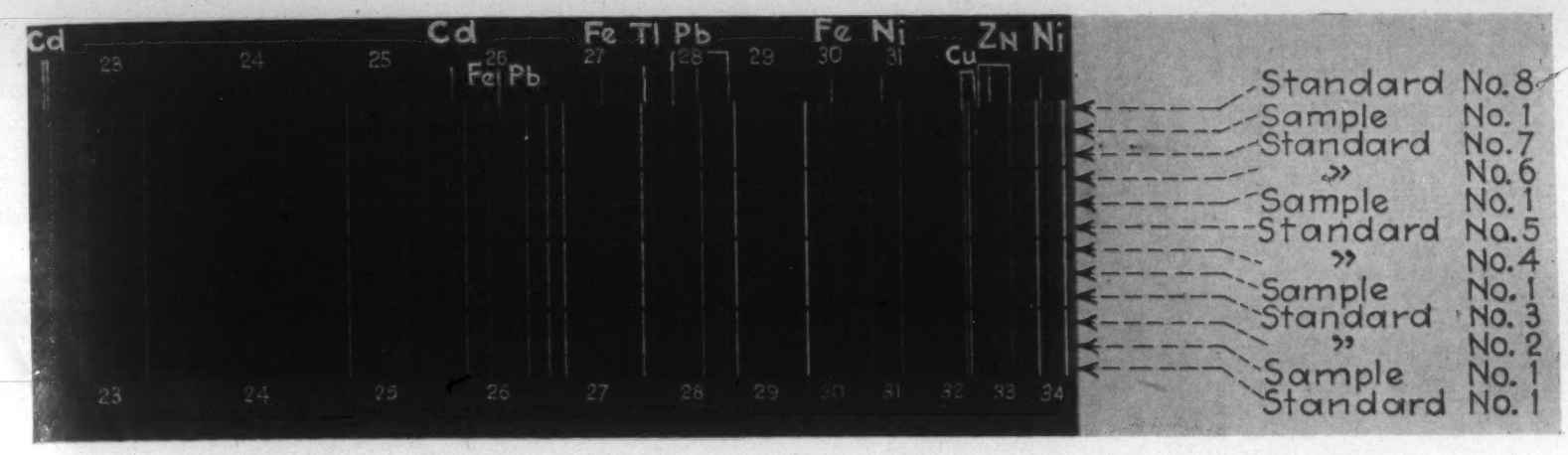
Wolfe claims that "the method of spectrographic analysis devised by Duffendack, Wolfe and Smith[31] is the most accurate and one of the quickest ones yet discovered" and "has been used in obtaining the data which is discussed in this[15] paper." Curves are given in which the logarithm of the ratios of the relative intensities of a selected line of the main constituent is plotted against the percentage of the desired element.

Contrary to the usual limits the curves cover a range extending well over 1 per cent. Thus that given for aluminum in nickel (Fig. 1) ranges from 1 to 5 per cent based on a comparison of the aluminum line at 2660 Å, with that of nickel at 2746 Å. For lower percentages a line of greater sensitivity is needed. Curves for magnesium (0.005-0.055 per cent) in zinc alloys, Barium (0.02-0.22 per cent) in nickel alloys with and without 20 per cent copper, and chromium (0.10-1.2 per cent) in nickel are also given.

The plotting of these curves has been based on the use of samples the composition of which is "accurately" known from chemical analysis. Failing that information it is assumed that resort would be necessary to data obtained by the comparison standard method obtained from carefully compounded synthetic solutions as outlined by Nitchie[32], Fuller and Standen[33], Lamb[4], and Hall in the method submitted to the A.S.T.M. for copper, bismuth, silver and nickel in pig lead[34]. No sensitivities are stated for the latter method but presumably it is within the range of ±10 per cent found by repeated experience to be the reasonable expectancy of the comparison standard solution method for a number of elements and compositions. This expectancy, as given in the method for lead, iron, and cadmium in zinc[35] or zinc alloys[36], appears true whether measurement of intensity and/or opacity (Duffendack and Wolfe differentiate[17]) is by visual, photometric or logarithmic wedge sector procedure.

Lamb[4], whose procedure is stated to be suitable also for cadmium compounds, cadmium alloys and in particular magnesium in cadmium base bearing alloys, makes no specific claims as to percentage of error but does discuss sampling and metallic electrodes. There appear to be no previous references on the spectrographic determination of impurities in cadmium, but zinc has been the subject of experimentation by Smith[45] who worked, as did Gerlach and Riedl[37] with metallic electrodes using arc and condensed spark. The latter authors indeed tried interrupted and continuous arc as well and have with Smith demonstrated that conditions for uniform exposures can be fairly well controlled, but Lamb in pointing out certain disadvantages even with the improvements of Slavin[38] (arcing of pulverized evaporated salts in graphite electrodes) refers to the use of solutions[32,33,34,35,36] and [39].

In the three methods submitted to and adopted by the A.S.T.M.[34,35,36] graphite electrodes, with the lower and positive one recessed to receive the sample or standard solution, are used. The procedure in all three cases is based upon that recommended by Nitchie[32].



Spectra Showing Typical Analysis of Samples of Commercial Cadmium. (From the paper[4] by Miss Lamb.)

Again Wolfe[15], for example, claims "Analyses can be made using a single exposure of the unknown" and "The accuracy of the method, with satisfactory unknowns, is about ±5 per cent. This will vary slightly for different elements and for different concentrations of the same element." If the abstractor understood correctly the spirited discussion that arose at the session over this and related points, a number in the audience were not prepared to accept claims for greater than 10 to 20 per cent precision and then only for amounts of the particular element under 1 per cent. Certainly the use of the term "accuracy" may

Table III.—Spectrographic Analyses of Several Runs of the Same Alloy

Alloy	Spectrographic Analysis, Mn, per cent	Chemical Analysis, Mn, per cent
9849	0.060; 0.063; 0.065	0.056; 0.06
9849	0.056; 0.060; 0.063	
9807–10	0.161; 0.167; 0.163	0.17; 0.15
9807–10	0.161; 0.159; 0.159	
6627	0.203; 0.218; 0.222	0.21; 0.22
6627	0.230; 0.209; 0.225	
9850–3	0.527; 0.639; 0.607	0.54; 0.54
9850–3	0.491; 0.548	
5939	1.616; 1.548; 1.491	1.53; 1.55
5939	1.403; 1.437	
Alloy	**Spectrographic Analysis, Si, per cent**	**Chemical Analysis, Si, per cent**
9799–1	0.057; 0.065; 0.069	0.036; 0.089; 0.059
9809–1	0.117; 0.126; 0.111	0.16; 0.16
9809–1	0.131; 0.125	
9795–12	0.188; 0.190; 0.213	0.19
9807–6	0.279; 0.266; 0.286	0.27; 0.23
9807–6	0.241; 0.263; 0.277	
9850–2	0.617; 0.629; 0.619	0.66; 0.76
9850–2	0.618; 0.611; 0.595	
9799–4	1.333; 1.638; 1.610	1.13*; 1.40*; 1.59; 1.60

* These two samples were possibly not completely dehydrated.

Table IV.—Prepared by Abstractor from Owens and Hess Data

	Deviation from Spectral Average					Deviation from Chemical Average				
Manganese	Range	Low	High	Ave.	Precision, ± %	Range	Low	High	Ave.	Precision, ± %
9849	0.009	0.056	0.065	0.063	10	0.004	0.056	0.060	0.058	3
9849		—0.002	+0.007				—0.002	+0.002		
9807–10	0.008	0.159	0.167	0.162	3	0.02	0.15	0.17	0.16	6
9807–10		—0.003	+0.005				—0.01	+0.01		
6627	0.027	0.203	0.230	0.218	7	0.01	0.21	0.22	0.215	3
6627		—0.015	+0.012				—0.005	+0.005		
9850–3	0.116	0.491	0.607	0.562	13	0.00	0.54	0.54	0.54	Check
9850–3		—0.071	+0.045				—0.00	+0.00		
5939	0.213	1.403	1.616	1.499	8	0.02	1.53	1.55	1.54	0.60
5939		—0.096	+0.117				—0.01	+0.01		
Silicon										
9799–1	0.012	0.057	0.069	0.064	10	0.053	0.036	0.089	0.061	45
9799–1		—0.007	+0.005				—0.025	+0.028		
9809–1	0.020	0.111	0.131	0.122	9	0.00	0.16	0.16	0.16	Check
9809–1		—0.011	+0.009							
9795–12	0.025	0.188	0.213	0.197	8	....	....	0.19	....	.....
9795–12		—0.009	+0.016							
9807–6	0.045	0.241	0.286	0.269	10	0.04	0.23	0.27	0.25	8
9807–6		—0.028	+0.017				—0.02	+0.02		
9850–2	0.034	0.595	0.629	0.615	3	0.10	0.66	0.76	0.71	7
9850–2		—0.020	+0.014				—0.05	+0.05		
9799–4	0.305	1.333	1.638	1.527	13	0.47	1.13	1.60	1.43	20
9799–4		—0.194	+0.111				—0.30	+0.17		

be questioned when precision or better still reproducibility was meant. Most assayers and many chemists realize that a method may give reproducible results and meet a certain precision and yet not be accurate.

Owens and Hess[7] claim "a degree of precision and accuracy equal to that of routine chemical analysis" and show (Table III) figures in support, obtained spectrographically by several runs of the same alloy (one or more areas) on different plates. Of sensitivity, cost, speed and precision the last is by no means the least. The abstractor has, therefore, prepared Table IV from the data in their Table I, the better to bring out the efficiency of the method both of itself and relative to the chemical analyses. Apparently the authors usually have no difficulty in reaching a precision of 10 per cent whereas Duffendack and Wolfe offer the opinion in their patent[17] "that any method based upon a comparison of the strengths of spectra lines as recorded on a photographic plate is necessarily unreliable." The erratic figures obtained for the silicon in sample 9799-4 by either method suggest possible segregation. The same appears true of the manganese in sample 5939.

(To be concluded)

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Controlled Atmospheres in Steel Treating—II

A Correlated Abstract

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THE FIRST PORTION of Part II of this correlated abstract on Controlled Atmospheres, dealing with "Cost and Action of Different Usable Gases," was published in the August issue. The installment in this issue includes the rest of Part II and all of Part III on "Furnaces in which to Apply Controlled Atmospheres." The last portion of this important discussion will deal with "Correlation of Experiments and Experiences."

Partly Burnt Hydrocarbon Gases—CO—CO_2—H_2—H_2O—N_2

The pure or cracked hydrocarbon gases and the other fuel gases all contain much hydrogen, either free or combined and, except the producer gas, all will produce soot on heating without addition of air.

In order to get more stable gases and to work chiefly with the CO:CO_2 equilibrium rather than that of CH_4:H_2, it is customary, for bright annealing, to partly burn the gases with a deficiency of air, oxidizing the CH_4 or other hydrocarbons to CO, CO_2 and H_2O, but leaving some H_2 unburnt. Common ratios are 3 volumes air to 1 volume city gas, or 6 volumes air to 1 volume natural gas. It is usually considered necessary to dry the gas so made, by chilling it to condense moisture, and often to dry it still further by the use of silica gel or activated alumina. (Figs. 21 and 22.)

The partial combustion is often carried out over a catalyst in order to make sure that all free O_2 has been combined before the gas gets into the muffle. The nitrogen of the air dilutes the gas so that city gas, say

Fig 21. **A chemical plant which makes gas for controlled atmospheres by burning regulated amounts of gas and air and refrigerates the products of combustion, to throw out water vapor. Surface Combustion Co. "D.X." gas preparation units at Detroit Steel Products Co.**

at $1.00 per M, is converted into a gas of about 6.5 per cent CO, 6.5 per cent CO_2, 9.5 per cent H_2 and 77.5 per cent N_2 whose raw material cost falls to about 35 cents per M. Natural gas at say 60 cents per M is converted into a gas of say, after drying, 9.5 per cent CO, 6 per cent CO_2, 9.5 per cent H_2, 2 per cent CH_4, and 73 per cent N_2 with the raw material cost only about 10 cents per M.

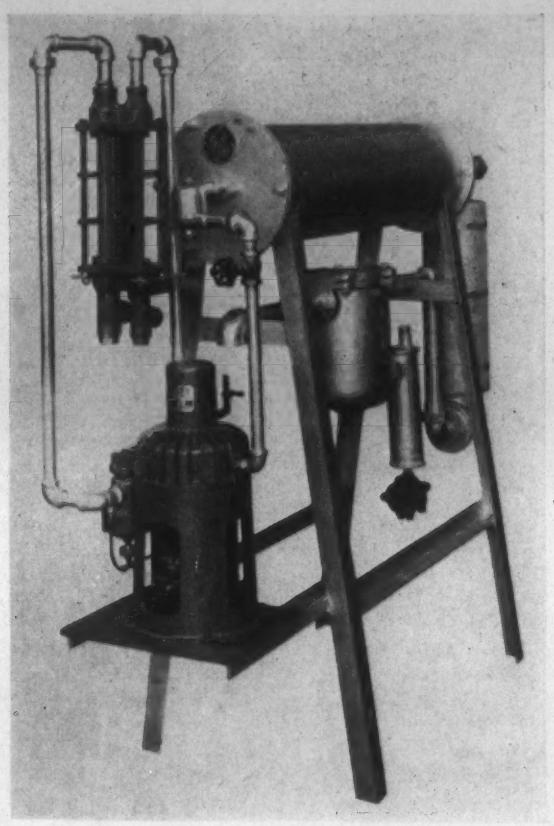


Fig. 22. The "gas-factory" for partial combustion of gas to provide controlled atmospheres. General Electric make.

Such a gas used without removal of moisture in a continuous sheet normalizing furnace, with a temperature of 1880 deg. F. in the hottest zone, did not give freedom from oxidation, but it did produce a thin, light, glossy scale easily removed in pickling.

Small converters for the partial combustion of city gas, natural gas, butane, etc. into these mixtures containing 75 to 80 per cent of the free N_2 of the air have been developed for continued formation and drying of gas on the spot. Gases that are practically sulphur-free are preferred as raw material.

The relatively low cost of converted gases and the availability of the raw materials justifies their wide use. However, the process for making and drying them needs careful control and some users feel that without a "laboratory man" to handle the conversion, which is really a chemical manufacturing process, the equipment may get out of adjustment and the gas fail to serve its purpose.

One man who has given this problem much thought puts it, "a furnace is a tool, atmospheric control is another control put upon that tool to enable it to turn out better and more uniform work, and this control of the atmosphere must be by some method that can be used in the shop by ordinary intelligent labor."

It should be recalled that the composition of the gas as it comes from the apparatus for partial combustion may not be that of the gas as it reaches the work, for some of the constituents may react further with each other, especially under the catalytic effect of a steel surface.

One laboratory worked with various mixtures of pure gases passed over steel samples in an electrically-heated silica tube furnace and then repeated the tests in an externally gas-heated silicon carbide muffle, and found marked differences, ascribable only to the catalytic effect of the different refractories. It should also be remembered that in the sampling of a hot gas mixture capable of reaction, the material of the sampling tube may have a catalytic effect, so that sampling through a fused silica tube, a nickel tube, or a water-cooled steel tube, may produce samples of different compositions. Leysner[34] discussing the equilibrium in the $CO:CO_2$ gas mixture produced in the smelting of ZnO with C at 2000 deg. F., where the presence of CO_2 leads to the unwanted production of "blue powder," finds that the use of a retort containing Ni or CO alters the equilibrium so that the gas contains only 1 per cent CO_2 in a nickel alloy retort, when it would otherwise contain 4 per cent.

The sum of the combustible gases in flue gas or in a controlled atmosphere can be determined and indicated continuously, or recorded, by special devices on the market, such as that shown in Fig. 24. This affords an additional means of control.

Deposition and loss of water vapor during sampling, or neglect to determine water vapor content, may make gases of different action due to the moisture content.

Fig. 23. The gas from the equipment shown in Fig. 22 is fed, for example, to continuous hardening furnace like this one of G.E. make.

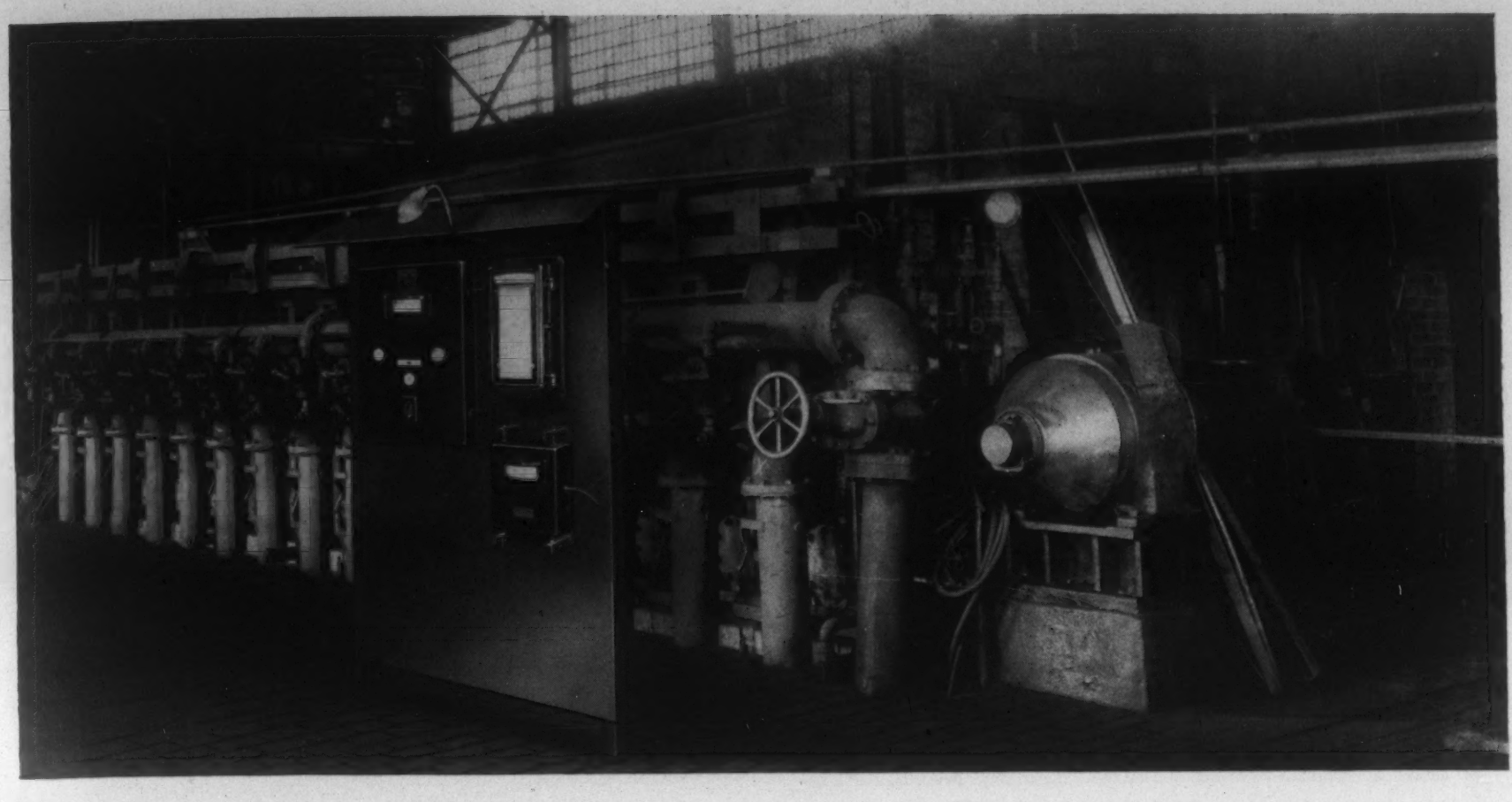


Fig. 24. A Recording Type Combustible Gas Analyzer Installed in a Heating Furnace. Bacharach Industrial Instrument Co., Pittsburgh.

The end products of the reaction between CH_4 and H_2O at various temperatures and pressures and the rate of reaction have been determined by Reder[35]. Alberts[36] has discussed the reactions that occur on heating mixtures of CH_4 and CO_2.

Kelley[37] advocated city gas cracked at 1000 deg. C. with the addition of steam, as an atmosphere for bright annealing. The composition suggested was 75 per cent H_2, 19 per cent CO, balance CO_2, CH_4 and N_2. The production of such a gas has certain practical difficulties. On one side of the balance, heavy carbon deposits are formed in the cracking unit, on the other, the resultant gas contains oxygen. It is nowadays more common to use partly cracked gas, or partly burnt gas, without addition of steam.

A complication in the use of such an atmosphere was later brought out by Marshall[38] who worked with CO, H_2 mixtures for the bright annealing of low-carbon steel at 650 deg. C. In the presence of iron these gases react as follows:

$$2CO \leftrightarrows CO_2 + C,\ CO_2 + H_2 \leftrightarrows CO + H_2O.$$

Hence the mixture, when fed into the hot furnace, contains CO, CO_2, H_2 and water vapor. If the $\frac{(CO)^2}{CO_2}$ and $\frac{H_2O}{H_2}$ ratios are controlled simultaneously, it is possible to avoid oxidation. Up to 1200 deg. F. Marshall finds that when CO and H_2 are produced from city gas for such use, the ethylene and free oxygen in the raw gas must be chemically removed. The ethylene would give trouble from soot production.

Maier[39] has described a process for converting a

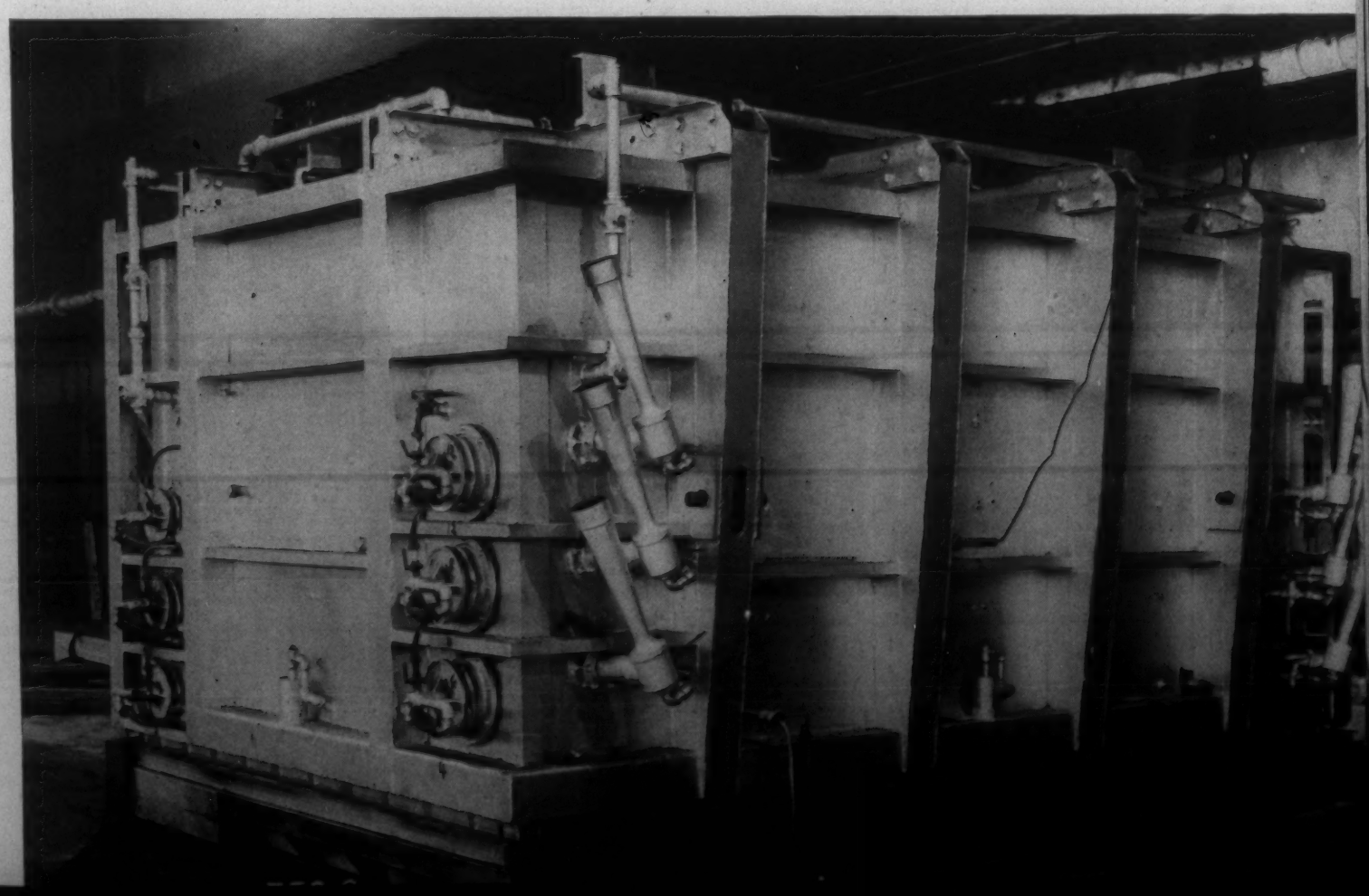


Fig. 25. Annealing cover, heated with gas-fired "radiant tubes," sending heat direct to the pile of sheeks instead of heating through a heavy box, thus avoiding a large part of the mass that formerly had to be heated up. A pre-burnt gas: air mixture is fed in to produce the desired atmosphere. Made by Surface Combustion Co.

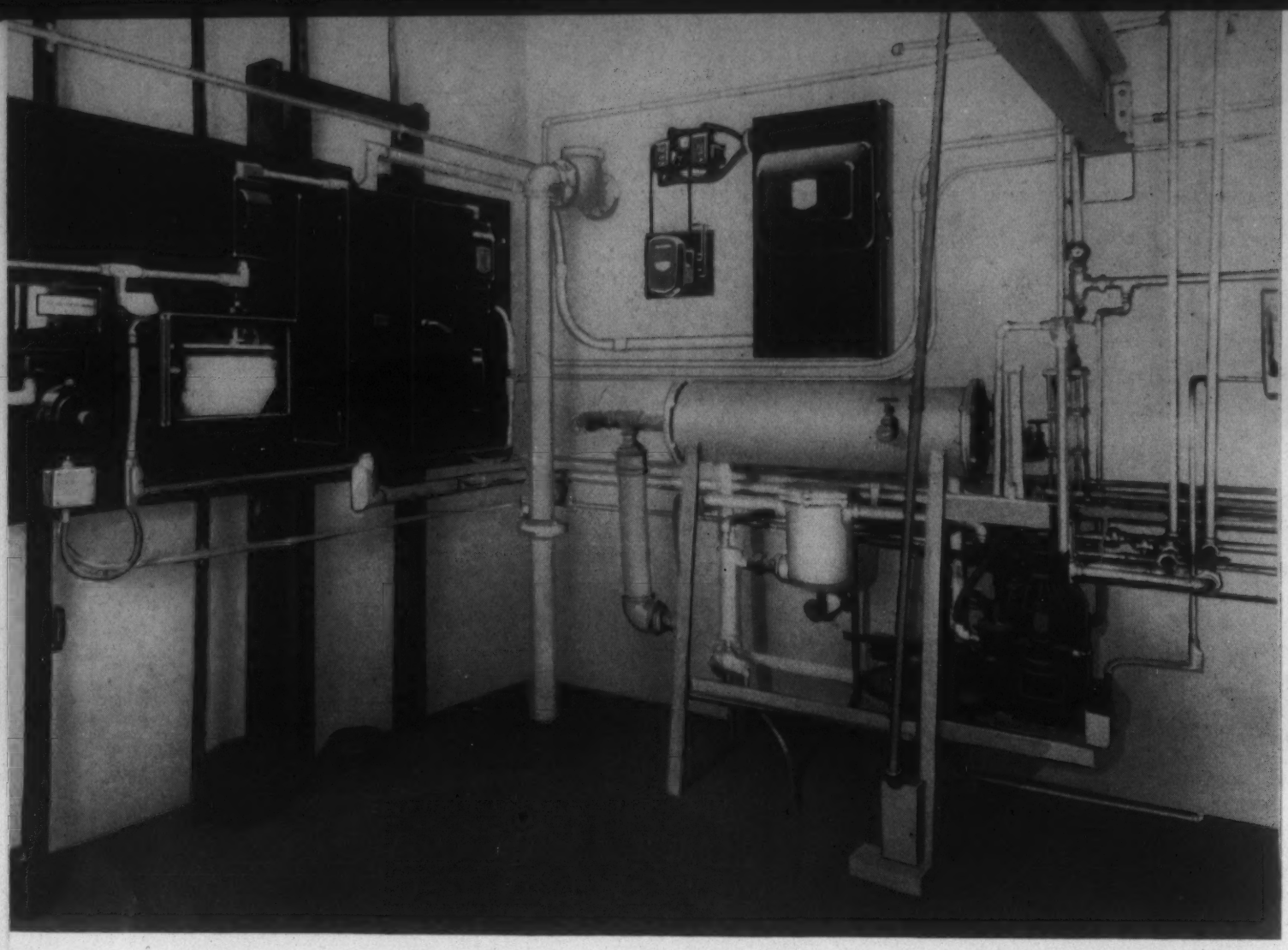


Fig. 26. Electrical control and 500 cu. ft. combustion type atmosphere controller using coke oven gas for G. E. Bell Type furnace in the plant of B. Greening Wire Co., Hamilton, Ont.

mixture of natural gas and air to a gas of about 42 per cent N_2, 36 per cent H_2, 19 per cent CO with under 1 per cent each of CO_2, H_2O and CH_4, by precautions that prevent side reactions and keep the H_2 from burning to H_2O. Such gas is sought for use as a reducing agent in ore-smelting.

Mort[40] remarks that in box annealing, where the pots are filled with raw gas to prevent oxidation, the gas must be clean, have a minimum of O_2 and be absolutely dry, and comments that, when a gas such as city gas is used, it may happen that the sheets in one box out of a dozen connected to the same line may show blue edges, without apparent reason. In discussion of this paper, Allison suggested that the gas may contain ethylene which may not be cracked to the same degree in the different pots. The mechanism by which ethylene, cracked or uncracked, could oxidize the steel is not apparent.

One user fills the annealing boxes with gas of approximately 6 per cent CO, 6 per cent H_2 made by partial burning of natural gas with about 5 to 6 volumes of air and finds that this gives a bright sheet at 1200 deg. F. (See Fig. 25).

A new installation is now being put into service at one plant, in bright annealing cold rolled sheet for tin plate in a closed, electrically heated enclosure into which is passed partly burnt coke oven gas (gas: air ratio, 1:2½). A similar atmosphere is being used in annealing low and medium-carbon steel wire, and it is stated that there is no etching of the surface whatsoever, it being almost impossible to tell by appearance whether a coil has been annealed or not. The coke oven gas contains:

	Per Cent		Per Cent
H_2	56.9	CO	8.7
CH_4	22.6	CO_2	3.0
C_2H_4	3.0	N_2	5.8

and organic sulphur, 7 to 8 grams per 100 cu. ft. This is partly burnt, over a catalyst and dried in the apparatus shown in Fig. 26. The exit gas is approximately:

	Per Cent		Per Cent
N_2	80.5	CO_2	6.0
H_2	6.0	CH_4	1.5
CO	6.0	H_2O	trace

The work is held at 1350 deg. F. and cooled in the same atmosphere to 200 deg. F. The furnaces used are shown in Figs. 27 and 28.

Marshall's problem was to balance the $\frac{(CO)^2}{CO_2}$, $\frac{H_2O}{H_2}$ ratios so as to leave the surface unaffected. At this temperature there should be no appreciable carburization, for the steel is ferrite, not austenite. But that doesn't prevent the $2CO \leftrightarrows CO_2 + C$ reaction from taking place.

Marshall found that in 25 per cent CO, 75 per cent H_2 there was no oxidation or carburization but that the surface of the steel was etched and pitted. He does not comment on any carbon deposition, but ascribes etching to the reaction which frees carbon. He found that, with this mixture, the drier the gas the worse the etching.

By partial combustion of city gas and freeing the resultant gas from ethylene and from free oxygen (which must result from incomplete mixing in the burner) Marshall found that, when he took out all the CO_2 and all the moisture, and had left 8.5 per cent CO, 0.1 per cent H_2 and 91.4 per cent N_2, the gas did not affect the steel at all, and there was no etching. With moisture excluded and H_2 down to 0.6 or 0.8 per cent an atmosphere of 25 per cent CO and 2 to 7 per cent CO_2 did not affect the surface. That is, when he was dealing with the CO-CO_2 equilibrium alone, with negligible H_2, results were good. With around 5 per cent H_2, etching set in, in the presence of 23 per cent CO, 2 per cent CO_2. With 20 per cent CO, 8 per cent CO_2, 16.5 per cent H_2 and 2.3 per cent H_2O there was no etching, nor, with similar CO and CO_2, with 68 per cent H_2 and 14.5 per cent H_2O.

It was deduced that by controlling the $(CO)^2$:CO_2 ratio to 0.4 or less, the $\frac{(CO)\ (H_2O)}{(CO_2)\ (H_2)}$ ratio may run from 1.0 to 0.06 without etching. If this ratio is held

at 0.5 the $\frac{(CO)^2}{CO_2}$ ratio cannot exceed 0.5 without etching.

A partly burnt city gas made with a ratio of 3 air to 1 gas, and containing 6.4 per cent CO_2, 6.2 per cent CO, 9.4 per cent H_2, 0.6 per cent H_2O, balance N_2 was found to be without etching action, Marshall considers CH_4 up to 10 per cent to act only as a diluent.

As soon as H_2 enters the atmosphere, and it comes in from any commercial hydrocarbon gas, the H_2O content has to be under strict control. When CO_2 is present, it has to be balanced up by suitable amounts of CO. These individual balances are disturbed by the reaction between CO_2 and H_2. The partial combustion of commercial fuel gases thus brings up a complex set of balances reminding one of juggling several balls while walking a tight rope.

LaPelle and Carpenter[25] advocate, for bright annealing and normalizing, partly burnt natural gas or butane, free from O_2 and containing 4.5 to 26 per cent H_2, 5.5 to 14.5 per cent CO, 8.5 to 2.5 per cent CO_2, with methane up to 7.5 per cent. (See Figs. 29, 30 and 31).

In an article on controlled furnace atmospheres, LaPelle[41] advocates "processing" natural gas or butane, removing any residual oxygen and cooling to separate some of the water, to give a gas of 24 per cent H_2, 13.5 per cent CO, 4 per cent CO_2, 3 per cent CH_4, balance N_2, for use in continuous normalizing and deoxidizing. The atmosphere is described as "highly reducing."

Material brought from the hot rolls, without pickling and normalized in such an atmosphere, acquires a matt finish and has to be pinch-rolled for uses requiring a smooth surface. Cold rolled stock is said to retain its brilliance.

Austin[27] comments on the problem that arises when sheet or strip for tin plate, which has previously been irregularly oxidized, is put into a reducing atmosphere for normalizing or bright annealing. The oxidized areas are reduced to metallic iron and this tins more irregularly than a sheet pickled without inhibitor, and free from reduced iron. This difficulty has to be avoided in successful application of continuous controlled atmosphere to the normalizing of steel for tinning.

It is reported that a furnace, which has not been publicly described, is operating through which continuous cold-rolled strip is led for normalizing and from which it passes to a continuous tin-pot. Heating is by Globar units and the controlled atmosphere is produced by cracking a specially selected oil and leading the cracked gas into the furnace. If something went wrong and there was an air leak, such atmospheres would be highly explosive. Most of the effort on bright annealing seems to be directed toward the use of partly burnt gases of compositions that are less explosive, though still within the possible explosive range.

Another analysis of partly burnt natural gas, considered by a furnace maker as suitable for bright annealing, is about 9.5 per cent H_2, 9 per cent CO, 6 per cent CO_2, 2 per cent CH_4, made by a 6:1 air: gas ratio. This gas is cooled and refrigerated to drop out excess water vapor. According to some users the 6 air : 1 natural gas or 3 air : 1 city gas combustion mixtures are neutral to steel with up to about 0.4 per cent C but are decarburizing to higher carbon steels.

Oliver[42] has presented some extremely interesting data to illustrate the fact that a "city gas" or "natural gas" subjected to partial combustion with a regulated deficiency of air gives quite different results in different localities, i.e., the variation in composition of the raw gas gives different prepared gases. This will, of course, be extremely apparent when no effort is made to remove moisture, for a gas analysis of the prepared gas without reference to moisture content does not tell the whole story. Oliver suggests that it will be necessary for each operator to experiment until he hits a suitable composition to meet his own conditions. Several users state that there are too many variables to allow prediction of results from equilibrium curves and physico-chemical calculations and advocate intelligent experimentation.

Kinsel in discussion[27] of Austin's paper says that,

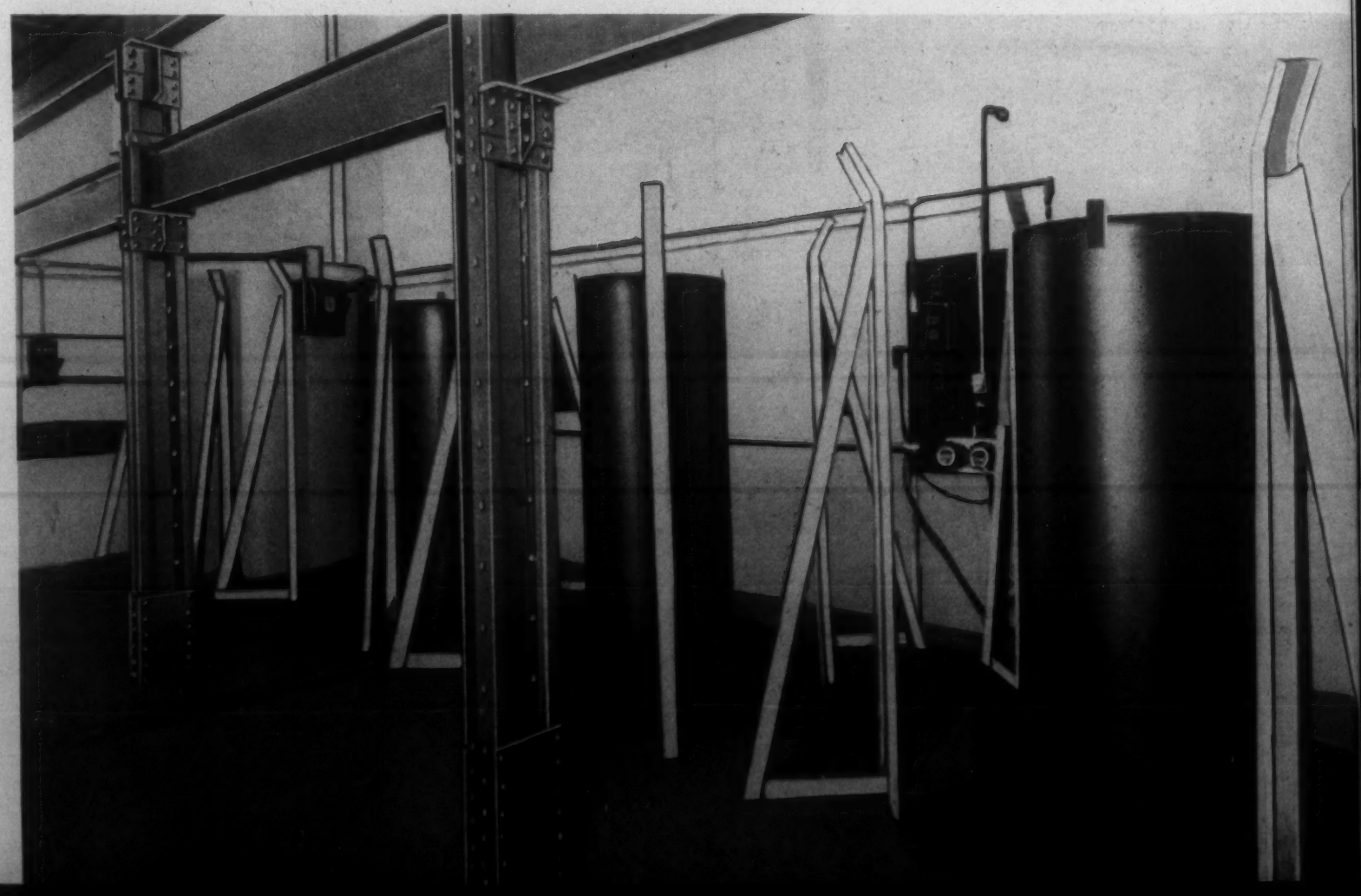


Fig. 27. General view of G.E. 96 kw. Bell Type furnace supplied to B. Greening Wire Co., Hamilton, Ont. Bases are below floor level.

at least for bright annealing, conditions are too complex for equilibrium diagrams to be applied directly to production in the case of the partly burnt hydrocarbon gas mixtures. His remedy is to avoid all carbon-containing gases and work with a pure dry N^2-H_2 mixture of low H_2 content, say around 10 per cent H_2.

There is certainly much to be said in favor of a less complex atmosphere. When the actions, not only of CO_2:CO, but H_2O:H_2 and perhaps CH_4:H_2 also, must be controlled according to the equilibria of Fig. 13, remembering that steels of different carbon content will react differently to each pair of gases, the control becomes complex. Drying to the practical absence of water vapor is generally considered necessary, as it simplifies the control and makes it less necessary to hold so exactly to a given air:gas ratio in converting the gas. Marshall[38], however, has been able to bright anneal in gas mixtures containing appreciable percentages of water vapor, if it is balanced by a sufficient hydrogen content, and if the CO:CO_2 ratio is held within definite limits.

Hydrogen-Free Atmospheres. N_2-CO and CO

The general aim in making the partly burnt gases from hydrocarbons seems to be to deal chiefly with the CO:CO_2 equilibrium, hence the increasing effort to get rid of water vapor as completely as possible.

In experimental work Bramley, Haywood, Cooper and Watts[43] heated Swedish iron for 40 hr. in 90 per cent CO, 10 per cent CO_2, and found no visible oxidation but oxygen analysis of turnings taken at different depths showed that the oxygen had increased at the surface, and that it had diffused to some little depth. The oxygen diffusivity constant was calculated and checked by determining the progress of deoxidation of Armco iron in H_2. The same authors give interesting data on the effect of O, S and P on the diffusion of carbon.

Only in carburizing is pure CO or a CO:CO_2 mixture actually used. Atmospheres of CO (or CO, CO_2) diluted with N_2 are sometimes produced within the furnace.

The Baily granular carbon electric resistor furnace, used for heat-treating anchor chain during the war[44], would have such an atmosphere with the resistor operating at high temperature and not much air filtering into the furnace. No published comment seems to have been made on scaling under such conditions, but Baily[45] noted a considerable reduction in scaling of ingots in soaking pits heated by granular carbon resistors. Under conditions where the scaling loss with producer gas firing of the soaking pit was 2.75 per cent, that in the electric furnace atmosphere was under 0.75 per cent, and most of this loss appeared to occur while the ingot was in the open air before charging to the soaking pit and after taking it out. (See Figs. 1 and 2, Part I, August).

The writer managed to obtain a "museum sample" of a piece of medium carbon steel that had been heated for quenching in a Baily granular carbon resistor furnace at about 1625 deg. F. for an hour or so, water quenched and drawn at 1050 deg. F. in a similar furnace. No special atmosphere other than that naturally occurring in the furnace or special precaution to avoid scaling was used. The specimen showed a very thin, adherent scale, beneath which there was an infinitesimal decarburized layer. The absence of carburization indicates that none occurred within the furnace, or that, if any carburized skin was formed, it was so thin as to be entirely removed by the scale formed when the hot steel was brought out into the air for quenching.

Atmospheres of N_2, CO and CO_2 right around the work, may be obtained by surrounding the work with carbon or graphite, as is done with the "Sentry blocks" or muffles and letting the carbon burn slowly as air seeps into the closed furnace. (See Figs. 32, 33).

Hankins and Becker[12], in an effort to avoid surface decarburization of spring steels in heating for quenching, tried placing a graphite cylinder around the specimens, within an electric furnace and found neither carburization nor decarburization in a Si-Mn steel heated at 950 deg. C. (1740 deg. F.), while there was a trace of decarburization with Cr-V at 850 deg. C. (1560 deg. F.). The specimens were only heated about 4 min.

The same steels and temperatures were used, with a 15 min. heating time, with the passage of a stream of CO about the work within the graphite tube. Car-

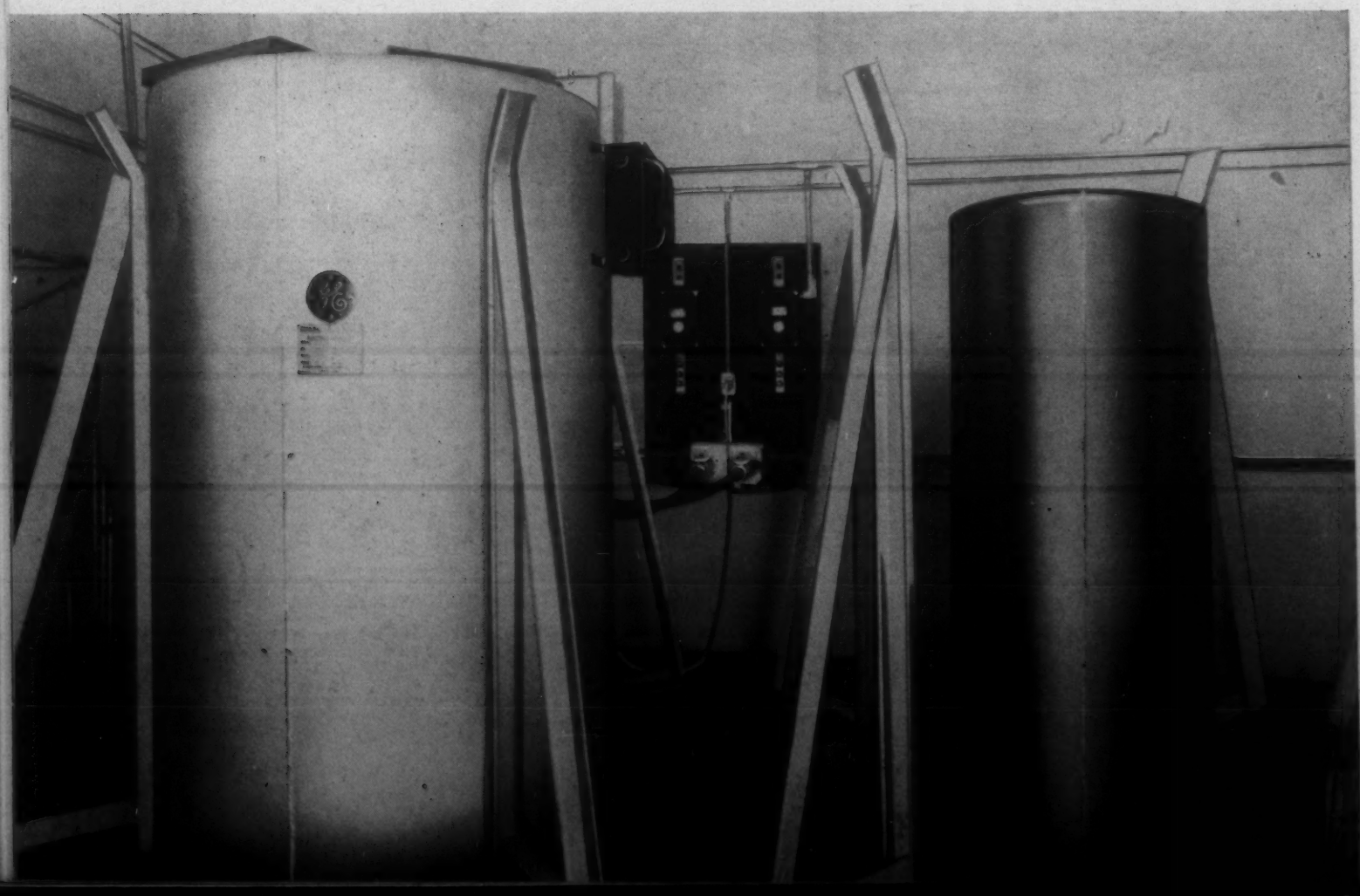


Fig. 28. No. 1 and No. 2 bases with hood and bell of 96 kw. G.E. Bell Type furnace in the plant of B. Greening Wire Co. at Hamilton, Ont., showing motor-starting switches and connections.

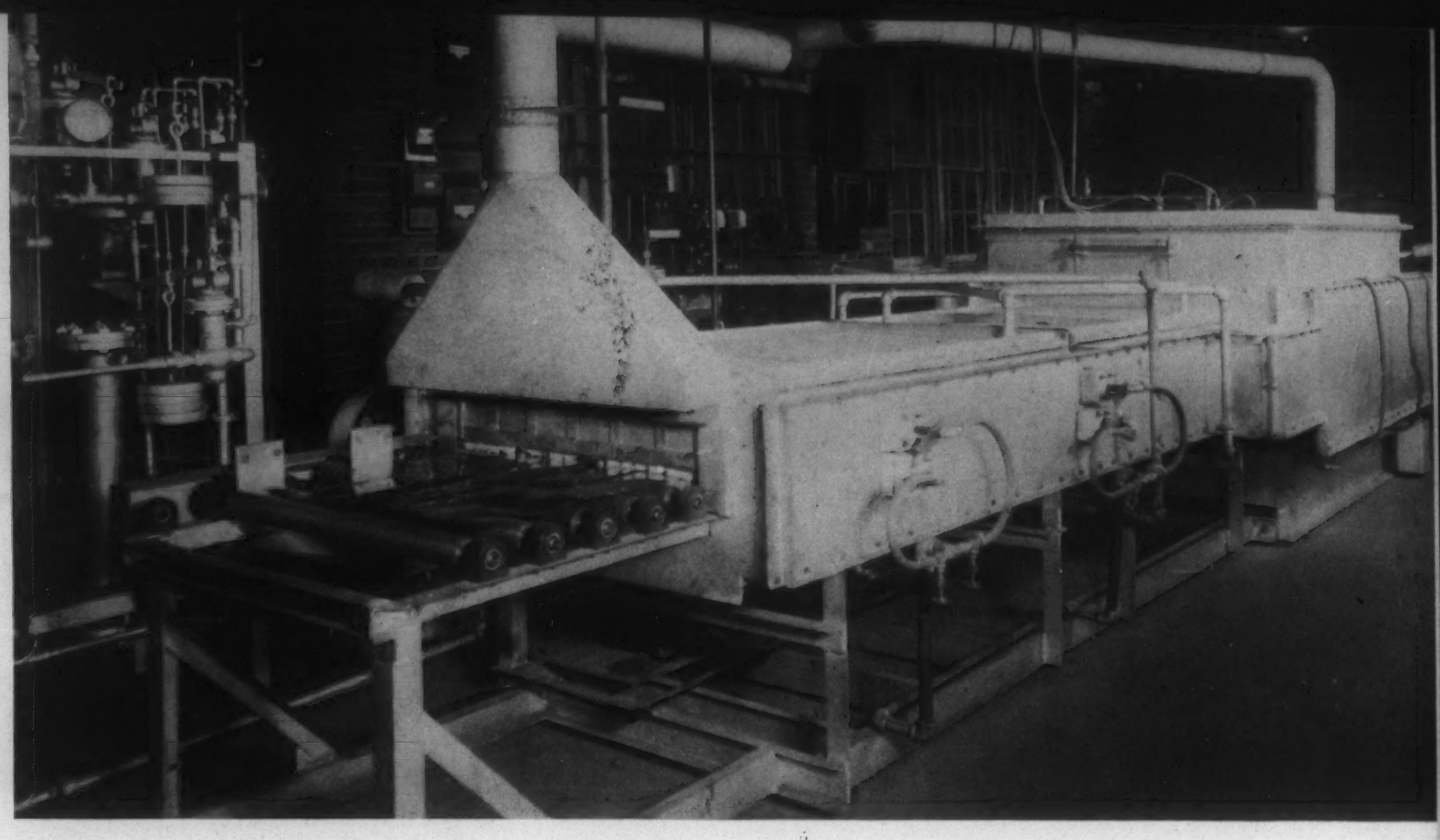


Fig. 29. Westinghouse continuous furnace for bright normalizing cold rolled strip.

burization was expected, but neither that nor decarburization could be detected by microscopic examination or hardness tests. But in both cases the endurance of the Cr-V steel was not quite as good as on a specimen from which the surface had been removed by machining and polishing, while the Si-Mn was entirely satisfactory.

In further work on the larger scale they surrounded the specimen with graphite powder and, when heating was done at 950 deg. C. (1740 deg. F.), both steels gave entirely satisfactory results in endurance, and neither carburization nor decarburization could be detected. It was therefore deduced that, in the previous treatments a neutral atmosphere would have resulted had the heating of the Cr-V steel been carried out at 950 deg. C. (1740 deg. F.), even though such a temperature would not be recommended for Cr-V steel.

Packing the work in cast iron chips produces a similar type of atmosphere to that produced by heating in graphite but one probably higher in N_2, since some of the O_2 of the air is used up in oxidizing the iron of the chips.

Schultz and Hülzbruch[19] found that such a treatment was only very slightly decarburizing; indeed, it was one of the best treatments they tried. The benefit was plainly ascribable to the graphite in the cast iron, since steel chips of 0.1 per cent C and 0.9 per cent C were not as efficacious. This simple expedient is considered extremely satisfactory by many users.

The only suggestion for an externally produced N_2-CO atmosphere appears to be that of Kinzel[46] who aimed to utilize a by-product from the distillation of liquid air, containing 95 per cent N_2 and 5 per cent O_2, by converting the O_2 to CO by reaction with charcoal. He states in his patent that the resulting gas of not over 5 per cent CO may be used for bright annealing, but there seems to be no record of any commercial utilization of this dilute CO. The later suggestion of Kinzel in discussion of Austin's paper[27], of dilute N_2-H_2 mixtures for bright annealing, would indicate that his interest had shifted away from the earlier suggestion. Liquid air residues are naturally available only at a few localities and it would be expensive to compress and ship the N_2-CO gas in cylinders.

Pure CO

Giolitti[47] has discussed the carburization of an 0.06 per cent C steel in pure CO. The reaction involved is $2CO \rightleftarrows CO_2 + C$, but there is no visible deposition

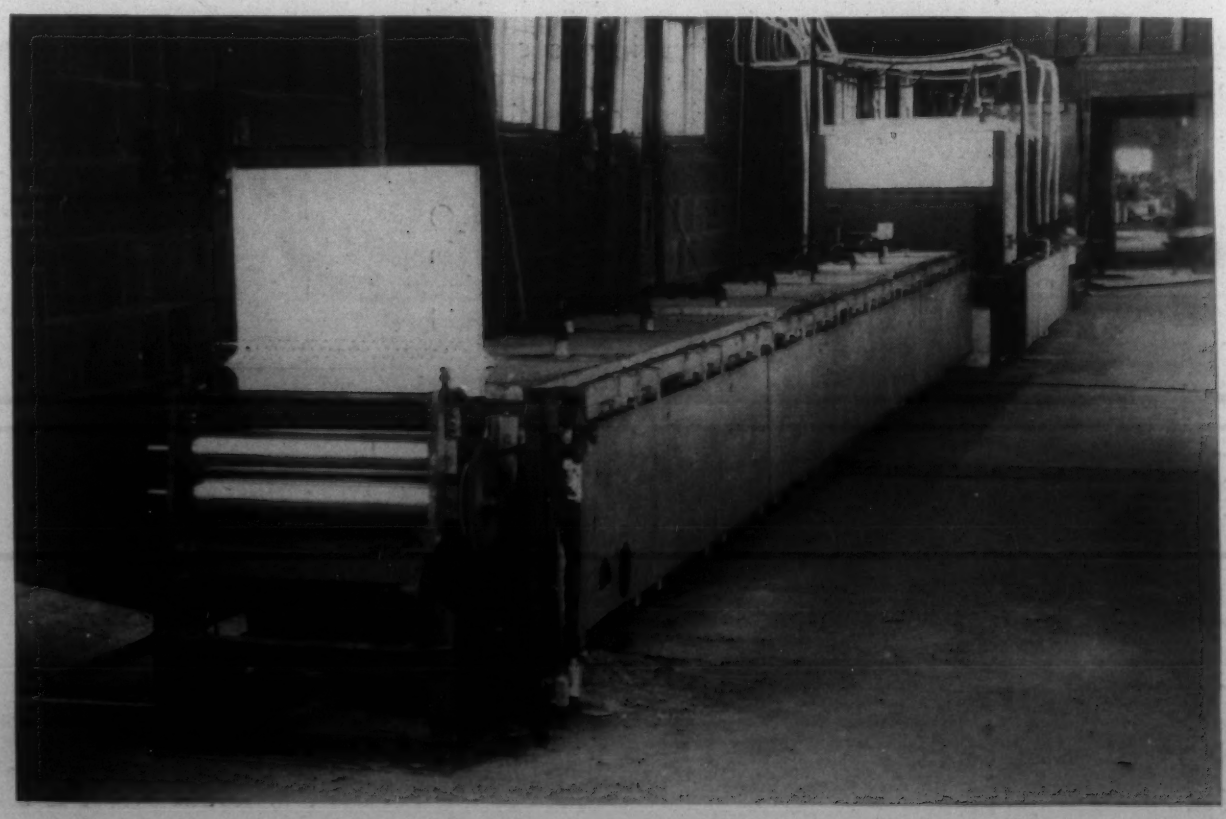


Fig. 30. Roller-hearth type furnace made by The Electric Furnace Company used for bright annealing cold rolled steel strip, special silicon steel strip and other strip products. In this type of equipment, strip products are annealed or normalized at temperatures ranging from approximately 1350 deg. F. up to 2050 deg. F., depending upon the materials involved and the physical properties desired in the finished materials. The operation of this equipment involves the use of suitable unreeling equipment at the discharge end, all of which is synchronized with the speeds of the driven rollers forming the conveying means in the furnace equipment.

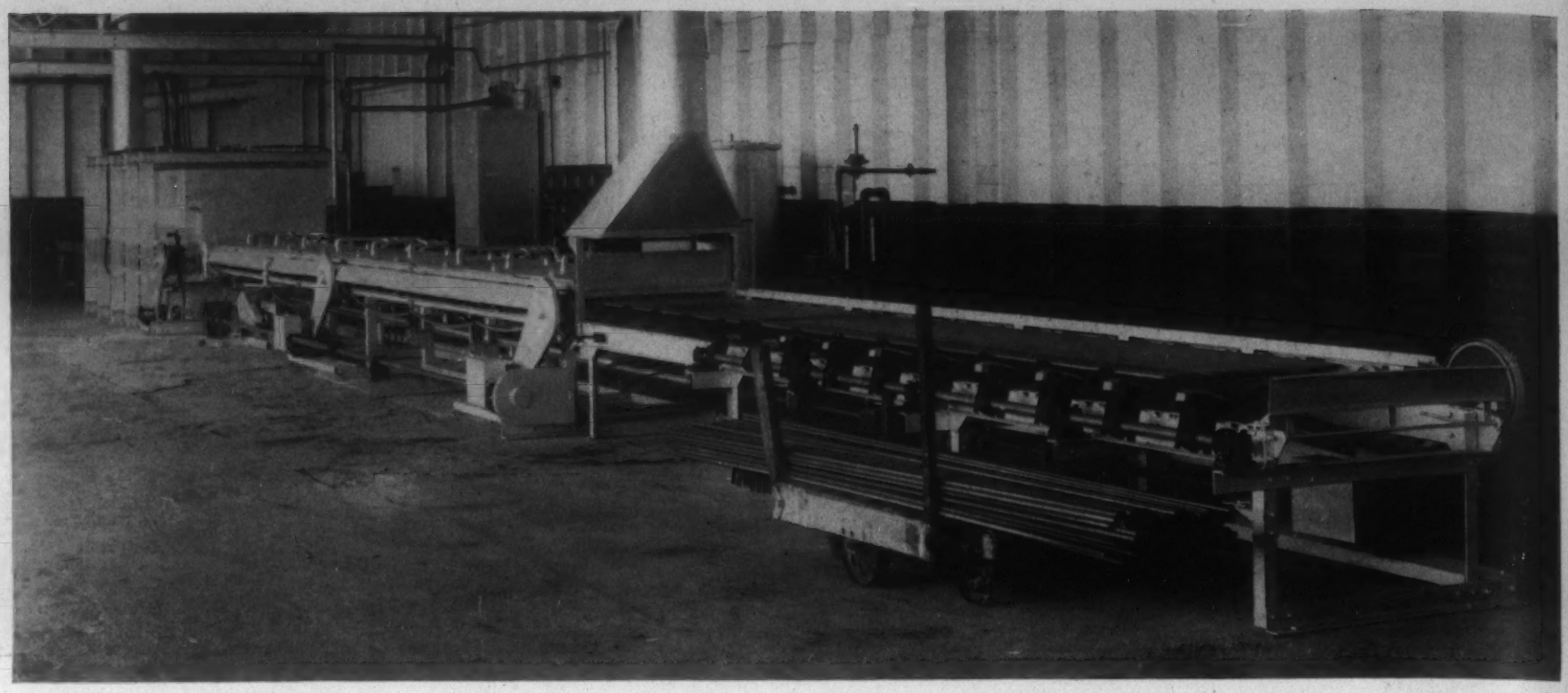


Fig. 31. Controlled atmosphere, continuous, roller hearth, conveyor type electric furnace with gas tight compartment for clean and bright normalizing steel tubing. The tubing is loaded at charging end and conveyed through the furnace on a series of rollers and automatically unloaded. The special atmosphere is produced in the generator shown in the background. The furnace is made by The Electric Furnace Company.

of carbon, for the carbon is taken into the austenite as fast as it is deposited. He found no cementation below 1450 deg. F. At 1450 to 1500 deg. F. the case thickness after 6 or 7 hr. in pure CO, was only 0.1 to 0.2 mm., but at 1650 deg. F. the case was 1 mm. thick after 5 hr., and 4 mm. after 3 hr. at 2000 deg. F. But the carbon content of the case was only about 0.30 per cent C at the surface, and only about 0.10 per cent at 3 mm. from the surface, in the 4 mm. thick high temperature case.

On higher carbon steels the reaction was similar, an 0.18 per cent C steel after 3 hr. at 2200 deg. F. in pure CO only had a 3.2 mm. case, with no hypereutectoid. An 0.94 per cent C steel was carburized to 4.1 mm. of hypereutectoid.

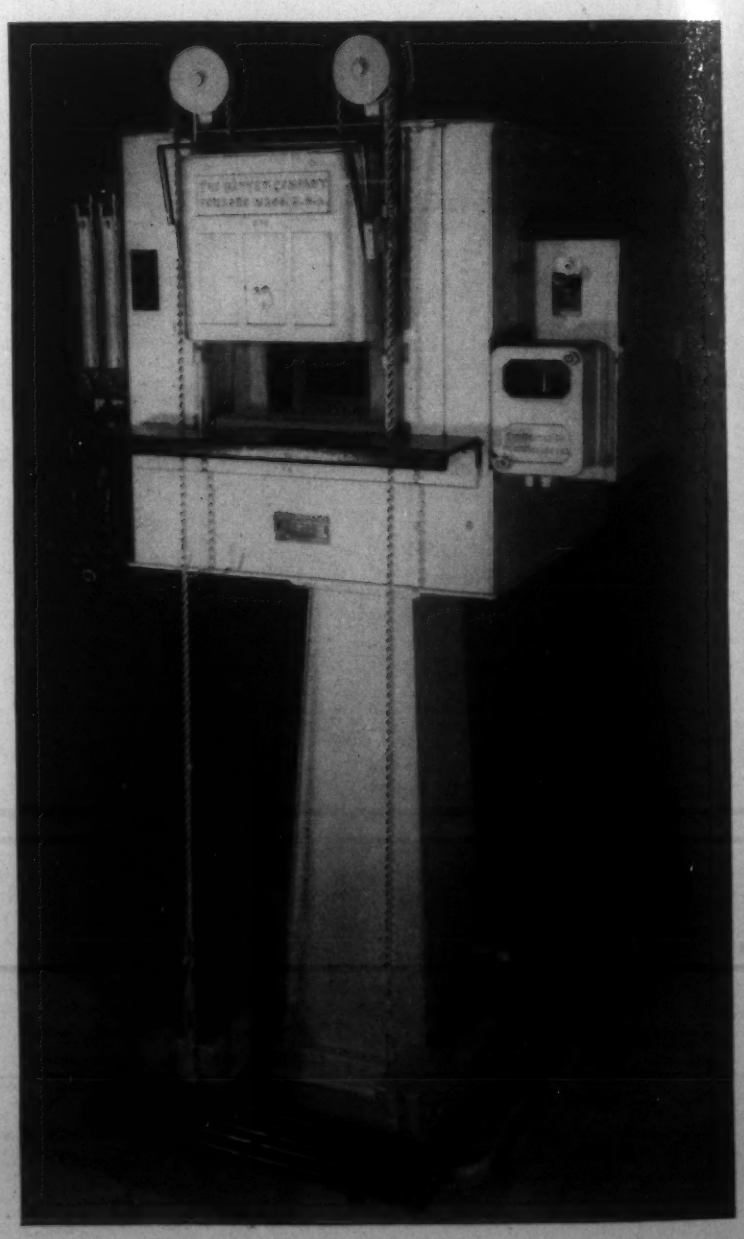
Giolitti states that in these cementations 0.5 to 2 per cent CO_2 with the CO is sufficient to "invert" the reaction, and stop cementation. While CO is important in the carburizing process, to produce a graded case rather than one sharply separated from the core, it is necessary, for rapid carburizing, to have free carbon in contact with the steel surface either as packing in pack carburizing, or as soot deposited by the cracking of hydrocarbons. Hence in gas carburizing CO is not used alone, in practice.

J. A. Dow (personal communication) states that he has obtained a case 0.032 in. deep, with 0.01 in. of hyper-eutectoid in 2 hr. at 1700 deg. F. in a CO, CO_2, H_2O, N_2 atmosphere in which the CO_2 and H_2O were kept below the amounts that would be in equilibrium with carbon at that temperature, but that the necessary rate of flow was so high that it would be impractical to carburize by this method in production.

Bramley and Jinkings[48] (whose work has been abstracted and commented upon by Cook[49]) studied carburization by pure CO. They noted that its carburizing action was weak, but that dry CO was a more active carburizer than CO containing traces of H_2O. Bramley with other coworkers then went on to study the behavior of CO plus hydrocarbons.

Fishel and Woodell[50], working with Armco iron, found pure CO to be only slightly carburizing at 800 deg. C, but increasingly so up to 1100 deg. C. Emmons[51] found no decarburization of a 1.15 per cent C tool steel in pure CO at 1100 deg. C. for 3 hr. but if CO_2 were present, decarburization occurred. In neither CO, CO_2 nor H_2 did he find decarburization below the critical temperature so he concluded that carbon must be dissolved in austenite before it could be attacked.

Fig. 32. Controlled Atmosphere Electric Furnace, Sentry made for Hardening High-Speed, Alloy and Carbon Steels. The atmosphere is controlled to suit the type of steel by muffle-shaped "Sentry Diamond Blocks" or else by a curtain of gas in front of the work.



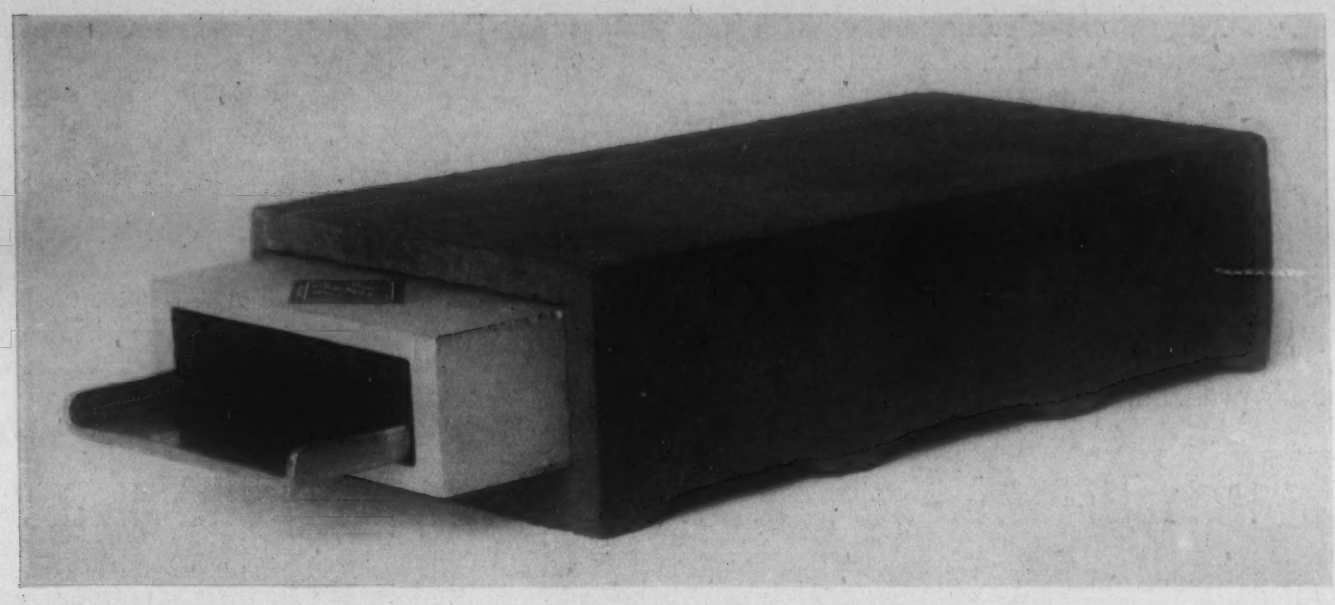


Fig. 32a. "Sentry Diamond" block, muffle and tray. Used in air to produce a CO, CO_2 atmosphere about the work by combustion of carbonaceous material.

Giolitti[47] found no appreciable power of CO to carburize below the critical range, the solubility of carbon in ferrite being too low to allow the rapid diffusion which occurs in austenite.

Schultz and Hülzbruch[19], report that pure CO does not produce carburization on steels of 0.50, 0.90 and 1.30 per cent C, but instead, very weak decarburization. They found traces of decarburization in the 0.50 per cent C steel at 750 deg. C., while the two higher carbon steels showed no decarburization below 950 deg. C. Austin[27] points out that in steel for hot galvanizing, some carburizing of low carbon steel may be helpful rather than harmful.

Air—N_2—O_2

Finally it should be remarked that air itself is the cheapest atmosphere, and that in a sufficiently confined space with a stagnant atmosphere, as in an annealing box or a batch electric or muffle furnace, the amount of oxygen may be so small that only the outside portions of the charge become scaled. In heating for hardening, slight scaling is less harmful than decarburization and if, in the attempt to avoid scaling by the use of some other atmosphere than air, a decarburizing gas is used, the results may be far less satisfactory than if scaling had been permitted. This accounts in considerable degree for the satisfactory results obtained in many electric heat-treating furnaces which do not use any atmosphere control.

In the heat treatment of white cast iron in sealed electric furnaces, all the oxygen of the air may be used up by reaction with carbon in the iron, and diffusion of carbon may be sufficient to restore the carbon at the surface if the heating is sufficiently prolonged after the oxygen has been used up.

Since a controlled atmosphere costs something to supply, the less the waste space in the furnace that is not filled by the charge and has to be filled with the special atmosphere, the better, as long as this is consistent with uniform heating which often demands having considerable waste space. High-frequency induction heating, with the heat generated in the metal instead of radiated to it, would seem especially applicable.

Absence of Atmosphere

Heating may be carried out in a vacuum, the disadvantages of which for a commercial operation are apparent, (though it is understood that Heraeus in Germany is doing some heat treatment of special materials in vacuo) or in lead baths or salt baths.

Unless a controlled atmosphere is provided in which the work may cool as it comes from the lead bath, the surface will take on a light scale or tarnish. A layer

Fig. 33. Sentry furnace, using Sentry blocks, at plant of Winters Bros. Co. Various sizes and shapes of blocks are shown on the shelf at the front of the brick wall. The blocks are intended to produce a suitable atmosphere without the injection of any special gas.

of molten salt may cling to the work and protect it while cooling, but has to be removed later. Salt baths may exert a decided decarburizing and etching or pitting action. Zingg[1] and coworkers claim to avoid decarburization in a $BaCl_2$ bath by maintaining an atmosphere of 2 parts CO 1 part H_2 over it, obtaining slight surface carburization by this means. Hankins and Becker[12] also sought to avoid decarburization by similar means. The addition of NaCN to salt baths to produce slight carburization and nitriding is well known. Bell[52] gives a brief discussion of the salt bath problem.

An expedient seldom resorted to, but sometimes deserving of consideration, is to cover the steel with something like borax to produce a protective layer on it during heating. This has been practically applied in the heating and forging of molybdenum tool steels, which are very prone toward decarburization and loss of molybdenum from the skin. Gregg[53] has described this practice.

Garratt[54] discusses the decarburization of 8 per cent Mo, 1.5 per cent W high-speed steel hardened in atmospheres of varying $CO:CO_2$ ratios and shows the benefits of a borax film.

Part III—Furnaces in Which to Apply Controlled Atmospheres

EFFICIENT combustion of fuel requires burning the bulk of the carbon to CO_2 rather than merely to CO. Hence fuel economy is badly sacrificed when we attempt to bathe the work in products of combustion so low in CO_2 that all scaling is avoided.

Fig. 34. An experimental high-frequency set-up of the Ajax Electrothermic Corp. to show the principle of continuous heat-treatment, one cylinder emerging from the furnace, another ready to be pushed in. There is almost no waste space in the furnace, so that very little gas would need to be fed in to produce a controlled atmosphere. A commercial furnace of this type, used for heat-treatment of razor blades in a controlled atmosphere is shown on page 85 of the April, 1935 issue of Metals & Alloys.

In heating in soaking pits, and for forging or rolling, the use of a smoky flame will reduce, but not eliminate scaling. When we seek to maintain the steel surface as intact as possible, it is imperative to separate the heating function from that of providing an atmosphere. The furnace must be made into a container for gases.

This is done with external heating in box annealing, or by the use of a metal or refractory muffle. An internal source of heat may be near the furnace walls, as when metallic or Globar electric resistors are used, or, with gas heating (when the operating temperatures are not too high) the fuel gas may be burned in heat-resistant alloy "radiant tubes," from which heat is radiated to the work. The desired atmosphere is thus led into a heating chamber in which a slight positive gas pressure is allowed to build up. (See Fig. 35)

Batch Furnaces

The problem of introducing the work and withdrawing it without altering the atmosphere must always be faced. In a batch furnace starting from the cold, the air must be purged out before the furnace is put into operation. It may take hours to displace the air absorbed in the refractory walls. In box annealing and the like where the work is cooled in the box, the controlled atmosphere must be maintained until the temperature has dropped below the temperature at which scaling will occur with infiltered air present.

The batch furnace works with a rather stagnant atmosphere so that less gas need be supplied per unit of time than in a continuous furnace. A curtain of burning gas, or that arising from burning charcoal, is often used in front of the door so that entering air meets this gas barrier rather than having free access. The atmosphere in the muffle or furnace itself may be provided by a jet of the desired gas, or it may be produced by the presence of charcoal, graphite, cast iron chips or the like.

Continuous furnaces are more difficult to provide with a desired atmosphere so that too much of the controlled atmosphere that is fed in and maintained under positive pressure will not be lost through the openings for charging and discharging, hence ingenious sealing devices are used. When the controlled atmosphere contains a poisonous constituent, such as CO, care must be taken that the gas bled from the openings is safely taken away. N. W. Hartz (personal communication) states that dangerous concentrations of CO have been measured around controlled atmosphere furnaces operating under positive pressure, and they appear to be quite common around the charging and discharging doors of furnaces with CO in the atmosphere, when the doors are opened.

However, there is now available a CO "alarm" which will ring a gong when the concentration of CO in the air reaches 0.02 per cent, so that hazard to workmen from CO poisoning can be averted. (See Fig. 35). If the work from a hardening furnace is automatically discharged into water or an aqueous quenching bath, entrance of steam into the furnace proper must be prevented, for example, by suction devices to carry away the steam before it can enter the furnace proper.

A series of gas burners, usually adjusted to give a highly reducing flame, burning above the exit of the furnace where the work is discharged into the water, and so hooded that the furnace gas has no other exit,

may supply enough draft to take out the water vapor and prevent its entrance into the furnace.

Since the operating conditions desired as to temperature and time, and the size of the articles to be treated vary so much in different plants, installations of continuous controlled atmosphere furnaces are engineered to fit rather than being stock products. Very ingenious mechanical engineering has been applied to the design of such furnaces. Probably the most difficult type of furnace to design and operate is the continuous normalizing furnace for continuous sheet or wide strip, where the work must pass from the heating zone to the cooling zone and cool with sufficient rapidity for good normalizing, and the atmosphere must be non-reactive at all the temperatures encountered. Continuous preheating and heating furnaces for hardening carbon and low-alloy tool steels come into a similar class. Here it may be necessary to provide not only graded zones of temperature but also graded gas compositions for each temperature.

Materials of Construction

The controlled atmosphere must meet not only the work but the muffle or other container, and in case resistors or radiant tubes are used, it must meet these as well. Thermocouples and their protecting tubes must be provided for temperature control. Many gas mixtures suitable for a given purpose, as far as their effect on the steel to be treated goes, are hard on materials of construction.

Moreover, the gas composition that is stable in contact with the steel may be unstable in contact with muffles or refractories, and catalytic effects thus produced may make some of the complex gas mixtures react and so alter the actual composition of the atmosphere that it is no longer the right one for the steel. Muffles of heat resistant alloys, too high in Ni content, accelerate the decomposition of CH_4 and other hydrocarbons. Propane, for example, will deposit more soot on some types of heat-resistant alloys than on others.

Ni-Cr resistors and thermocouples stand up best in an oxidizing atmosphere and deteriorate when covered with soot, or even in an atmosphere of a sufficiently reducing nature so that the protective oxide film is destroyed. New resistor alloys of Fe-Cr-Al are being introduced with claims that they not only operate satisfactorily at higher temperatures than do Ni-Cr alloys, but also that they behave well under reducing conditions. There has been too short a period of commercial use to appraise the accuracy of these claims.

Alternately oxidizing and reducing conditions are much more detrimental to the Ni-Cr alloys than a continuously oxidizing or reducing condition. Changing the atmosphere periodically through air infiltration due to opening a door may be very harmful.

Steam has a very definitely oxidizing effect on Ni-Cr alloys. In a continuous dry hydrogen atmosphere 80/20 Ni-Cr alloy resistor elements have been known to last 3 yr., while in a hydrogen atmosphere, with the door opened every half hour, they only last about a year.

West[55] states that under some conditions material can be kept bright in atmospheres that have not been dehydrated, "but for the protection of the equipment involved, it is desirable in all cases to remove a large portion of the moisture."

Resistors and Their Life

Reports as to life of metallic resistors, couples and radiant tubes are somewhat contradictory. Strongly carburizing gases are definitely bad for all of them. The carefully dried products of partial combustions from 3:1, air:city gas or 6:1, air:natural gas mixtures apparently get by without much bad effect in the lower temperature bright annealing furnaces, with too little data to tell much about behavior at higher temperatures.

It is no less than amazing that the "radiant tubes" within which gas and air are burnt so that the interior is at a high temperature and the outside is in contact with a non-oxidizing gas can be operated to give sufficient temperature head to the heat flow to the work. One would have expected that the tubes would crack in service and allow the combustion gases to leak into, and spoil, the controlled atmosphere. However, such tubes do seem to work as long as the operating temperature is not too high. Hepburn[56] has described the design of the tubes, and Owen[57] the construction and operation of an elaborate spring hardening furnace using such tubes with a working furnace temperature of 1500 to 1600 deg. F.

The tube material is stated to be ordinarily 38 per cent Ni, 15 per cent Cr, balance Fe unless high sulphur gas is burnt, when one of 12 per cent Ni, 38 per cent Cr, balance Fe is chosen.

If the atmosphere is reducing to impurities in the

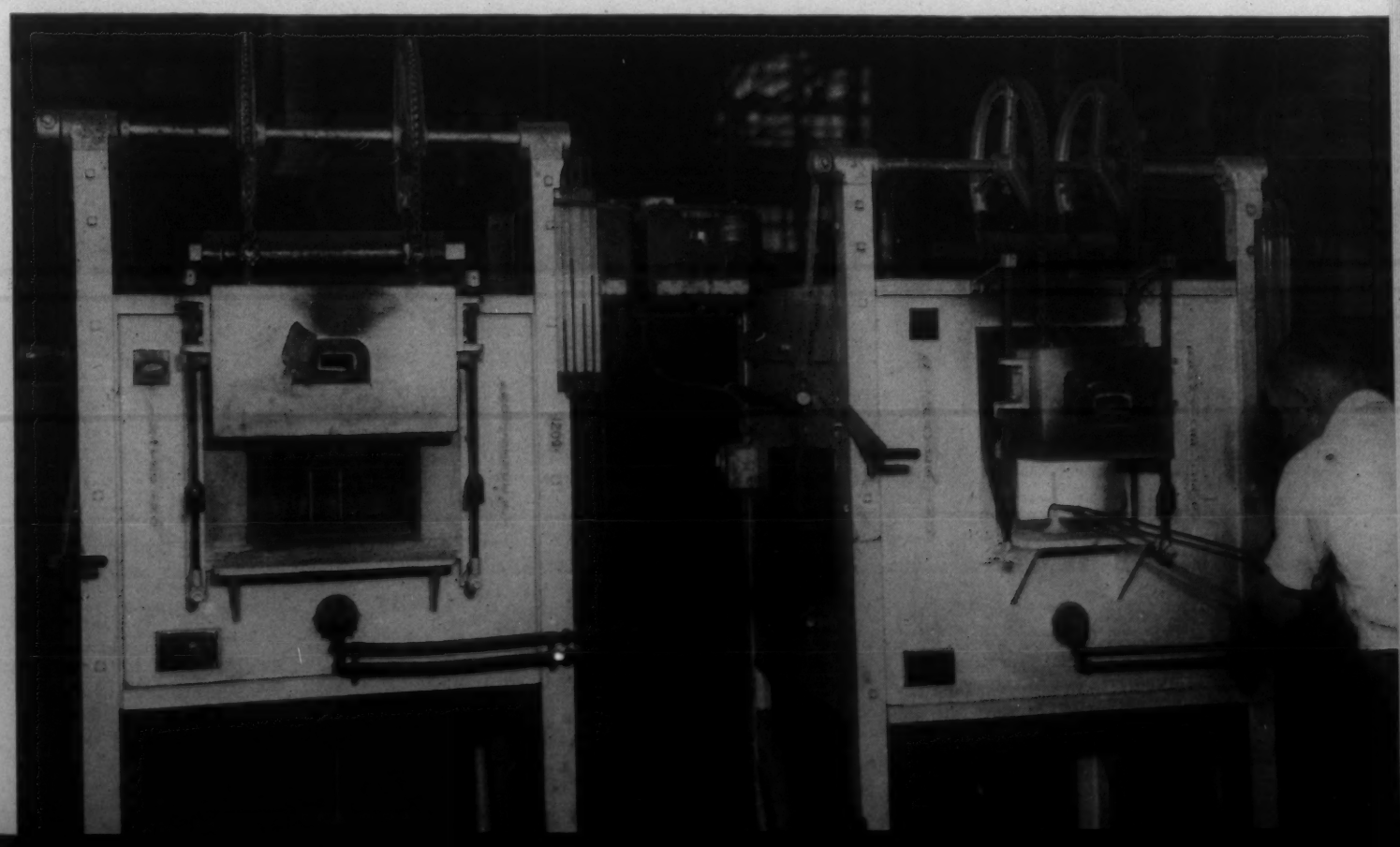


Fig. 35. A pair of controlled atmosphere furnaces at Thompson Products Co. for treating valves, tools and dies, both of Hayes "Certain Curtain" make. Preheat furnace at left has metallic resistors, high-heat furnace at right has Globar resistors. Both are supplied with gas : air mixtures, proportioned according to the readings of the pressure gages shown.

refractories, especially when operating at the higher temperatures, refractory failure may ensue. The porous, heat-insulating refractories would be very applicable for an internally heated furnace, from the heat-saving point of view, but they have drawbacks since they slow down the purging of the furnace from air after a shut down, because of the retention of air in the pores and if they are used with a gas that deposits soot, the deposition may take place within the pores.

Silicon carbide refractories are very useful as muffles because of their high thermal conductivity and

Fig. 35a. Carbon monoxide alarm, case opened to show the alarm gong. Manufactured by Mine Safety Appliances Co.

their inertness to various atmospheres. It is well known that they stand up quite nicely under oxidizing conditions, and it is reported that no deterioration has been noted after several years use with atmospheres high in hydrogen.

Similarly, the Globar (silicon carbide) resistor seems to be less subject to attack in reducing atmospheres than are metallic Ni-Cr resistors, but the makers do not recommend the use of H_2 or dissociated ammonia (N_2-H_2) atmospheres about the Globar resistors. Gases that break down and deposit carbon are undesirable, for the carbon deposited in the pores of the resistor alters its resistivity and may indirectly lead to breakdown of the resistor.

At resistor operating temperatures of over 2550 deg. F., CO_2 has an oxidizing effect upon the silicon carbide, but dry CO atmospheres are not harmful.

Water vapor is detrimental to these resistors. They withstand the products of partial combustion of fuel gases with a deficiency of air, if the water vapor is removed.

Nickel chromium resistor elements have been reported as standing up for 20 months, at a surface temperature of 2200 deg. F., in an atmosphere with 5 per cent CO_2, 15 per cent CO, 15 per cent H_2 made by partially burning city gas and dropping out some of the water vapor by passing through a cooling system. Service of 3 yr. or more in atmospheres varying from the above to pure hydrogen have been reported. One maker of resistor materials believes that longer life would be given if both sulphur and water vapor were absent, for the intergranular corrosion which embrittles the element is thought to be largely ascribable to those impurities in the gas.

It is interesting to note that water vapor is not only the bad actor in the furnace atmosphere as regards the steel being treated but also as to metallic and Globar resistors. Thus there is added reason for eliminating water vapor, or avoiding its production.

With the chemical engineering involved in the manufacture and control of suitable gases and the mechanical engineering involved in the design of furnaces it is obvious that a satisfactory solution for the problems of a given plant requires the cooperation of the plant metallurgists and of the furnace engineers who have given years of detailed study to such problems.

Sticking a gas pipe into any old furnace and letting a little gas trickle in won't solve very many of the scaling and decarburization problems of today.

(To be continued)

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Recent Progress in Steel Making Reported from Germany—V

A Correlated Abstract

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THIS is the concluding installment of this comprehensive and valuable series by Mr. Epstein. The four previous sections have appeared in the May, June, July and August issues, discussing respectively "Equilibria between Slag and Bath," "Gases in Steel," "Desulphurization in Basic Open-Hearth Steel" and "Defects in Steel." Several interesting developments are reviewed in this installment.—EDITOR.

Recent Developments

A FEW OF THE RECENT steel-making developments reported from Germany, dealing with slag control, use of Mn ore in the open-hearth charge, open-hearth slag tests, jarring of ingots during solidification, and direct rolling of molten steel are discussed in this, the concluding, installment of this abstract.

Fig. 24—Appearance of Open-Hearth Slag Tests; From Acid to Basic. Back[9]

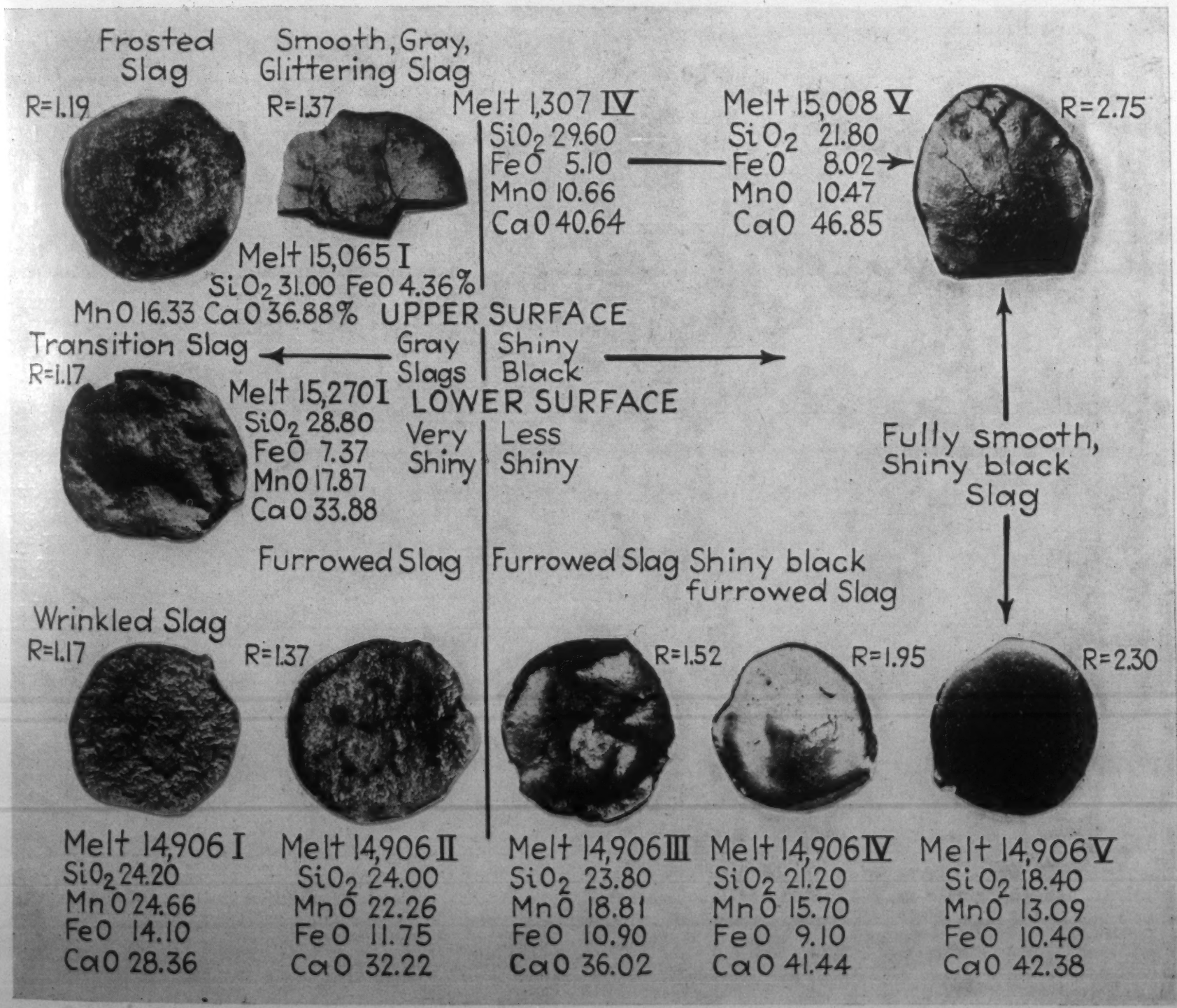


TABLE IV. Average Composition of Bath and Slag with Mn Ore and High Mn Pig Iron in Charge.

verein deutscher Eisenhüttenleute[45]

Type of Charge	Carburizer		Composition of Metal Bath									Slag	Mn Oxidation Mn in the Slag		
			Calculated Charge				After Melt Down								
	Charcoal, Kg.	Anthracite, Kg.	C %	Mn %	P %	S %	C %	Mn %	P %	S %	Slag After Melt Down			Per cent of Total Mn	Mn in Bath, Kg.
											SiO_2 %	CaO %	Fe %			CaO/SiO_2 Ratio	Wt., Kg.	Kg.	
Group I—About 1% Mn in Charge																			
(a) With Mn Ore	320.0	125	1.18	1.0	0.052	0.058	0.41	0.28	0.028	0.053	26.36	35.91	8.85	10.17	1.37	3,149	318	72.4	121
(b) With High Mn Pig Iron	125.0	...	1.11	1.05	0.054	0.053	0.18	0.26	0.035	0.049	24.42	33.88	10.11	11.75	1.39	2,881	331	75.8	106
Group II—About 1.5% Mn in Charge																			
(a) With Mn Ore	375.0	125	1.33	1.61	0.052	0.058	0.42	0.33	0.026	0.047	17.67	37.87	12.65	12.65	2.13	4,335	545	80.4	133
(b) With High Mn Pig Iron	....	...	1.11	1.57	0.053	0.048	0.34	0.35	0.024	0.033	17.05	33.62	14.64	14.78	1.98	3,577	528	78.2	147.4
Group III—Without Mn Ore or High Mn Pig Iron	227.5	125	1.12	0.43	0.053	0.059	0.43	0.29	0.047	0.056	23.41	43.66	8.57	6.38	2.03	1,081	55.9	32.9	113.5

Slag Control

Although Killing[44] noted as early as 1920 that the CaO/SiO_2 ratio of the slag profoundly affected its oxidizing power, particularly the residual Mn in the bath, the close relationship between the CaO/SiO_2 ratio and the FeO content of the slag has been fully realized only recently. No technical reports have as yet been made of the practical utilization of the fact that a low basicity results in a low FeO content of the slag, but some patents have been issued to German firms. An early patent (U. S. Patent No. 1,949,529, March, 1934) to the Allegheny Steel Co. also embodies this general principle; an addition of sand to the slag toward the end of the heat is made in order to decrease the FeO content in the manufacture of transformer sheet.

Similarly a patent to Wallmann, Halbrock, and Kumpmann (U. S. Patent No. 1,970,067, August, 1934) describes the addition of sand or glass to the slag after the lime has risen, in order to reduce the CaO/SiO_2 ratio to about 1.5 to 2. The resulting low FeO in the slag is stated to give a high residual Mn and to cause a reduction of Mn to the bath, so that less final deoxidation is necessary—this in spite of the fact that a large part of the Mn in the charge was added as Mn ore. The low basicity is alleged not to have caused a P or S pickup. The analysis of a heat made according to this practice is given as follows: C 0.22, Mn 0.72, Si 0.21, P 0.31, S 0.031 percent. Such steels are stated to be less susceptible to aging.

On the other hand, Kühn of the Vereinigte Stahlwerke has been granted patents (U. S. Patents No. 1,979,629, November, 1934, and No. 1,991,685, February, 1935), according to which a *highly basic slag held at a high temperature* is used instead of a less basic slag for the same purpose of reducing Mn and alloying elements like Cr from the slag to the bath. The initial charge is high in Mn in order to protect the Fe from undue oxidation; after much of the Mn has been oxidized to the slag the temperature is raised and extra lime is added at the same time up to two per cent of the charge or more if a high enough temperature can be attained.

At the high temperature a continuous reduction of MnO from the highly basic slag is stated to occur with a sharp rise in the Mn content of the bath, so that no ferromanganese need be used as a deoxidizer. Such steel is also alleged to have low susceptibility to aging. The reason probably is that steels in which Mn, and Si as well, are reduced from the slag and hence are better deoxidized, become fine grained on the subsequent addition of even a small amount of a strong deoxidizer. Although mention of grain size appears in German publications [46], no comprehensive discussion in German on the subject of grain-size control has been issued.

Use of Mn Ore in the Open-Hearth Charge

The German Steel Works Committee [45] has compared the effect of using Mn ore as against high Mn pig iron for making low-C steel. The tests were made in a 40-ton basic open-hearth furnace; the Mn ore contained about 50 per cent Mn and 10 per cent SiO_2; the high Mn pig iron contained about 4.3 per cent C and 5.6 per cent Mn. When using the Mn ore, enough Mn was reduced to raise the content of the bath to the same value as with high Mn pig iron. To effect this reduction of Mn, anthracite or charcoal had to be added to the charge, so that it would contain about 1 per cent C. The results obtained are summarized in Tables IV and V.

As shown in Table IV, about the same residual Mn was obtained whether ore or high Mn pig iron was used. As indicated in Table V, the melts without high Mn pig iron required more Fe-Mn at the finishing period. This was probably because the melts with Mn ore were charged with more scrap and thus gave greater oxidation. The furnace output was somewhat better with the high Mn pig iron. The Mn ore heats gave higher S after the melt down; this was probably because of the longer time of melt down and

TABLE V. Furnace Yield and Ferromanganese Used with the Practices Used.

	Furnace Yield with 40-ton Cold Charge	78 Per Cent Ferromanganese Used
Group Ia.....	5.4 ton Ingots per hr.	8.4 kg. per ton Ingots
Ib.....	5.7 ton Ingots per hr.	8.3 kg. per ton Ingots
Group IIa.....	5.2 ton Ingots per hr.	7.9 kg. per ton Ingots
IIb.....	6.0 ton Ingots per hr.	7.0 kg. per ton Ingots
Group III.....	5.0 ton Ingots per hr.	9.7 kg. per ton Ingots

consequent S pickup from the furnace gases and from the anthracite used; the ore itself may also have contained some S.

The conclusion was that, particularly with proper slag control, good results could be obtained with the use of Mn ore in the charge. About 1.25 per cent Mn in the charge appears to be sufficient for low-C steel, more than that being superfluous.

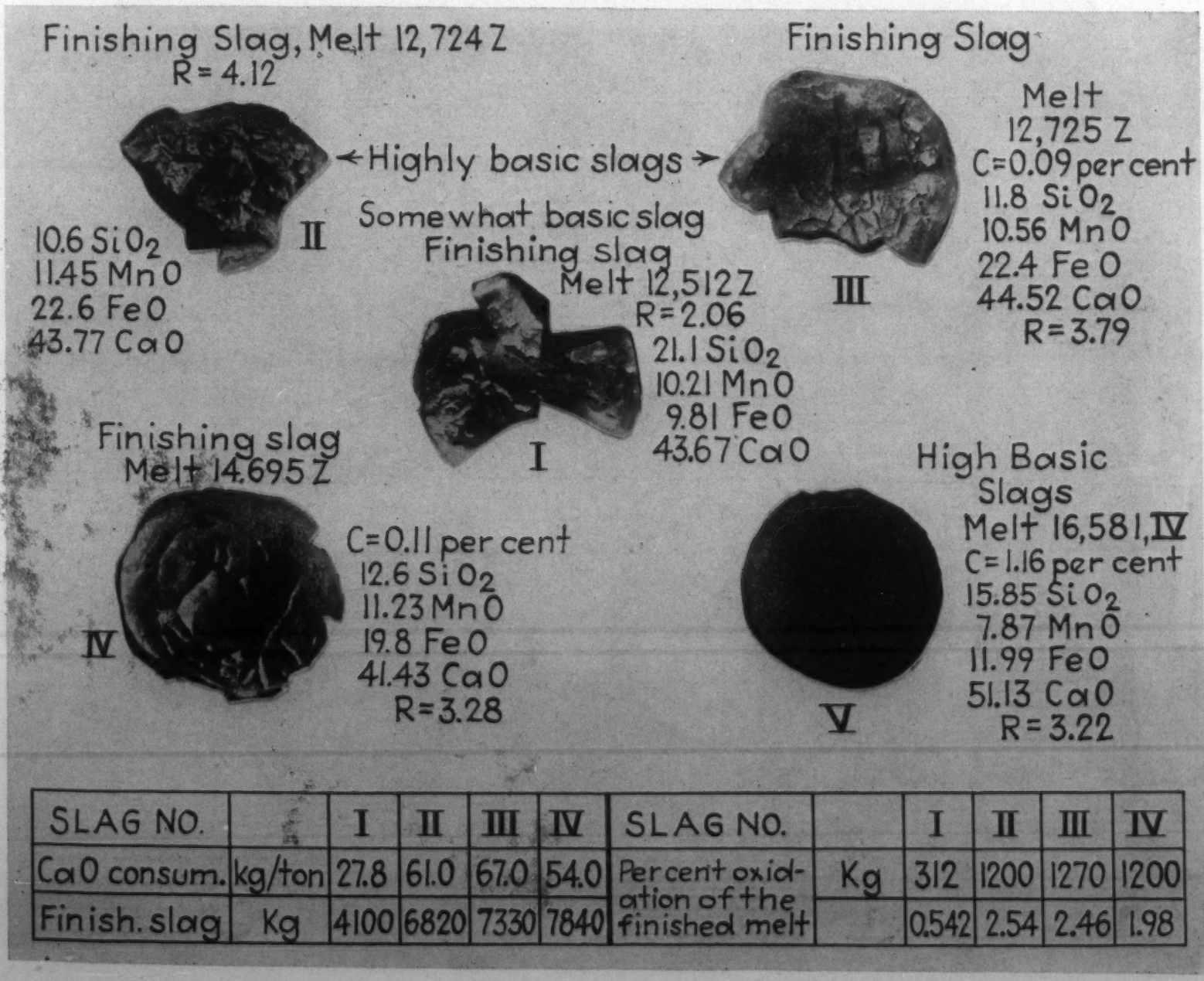
The mechanical properties of the steel made with the Mn ore were equal to those with the high Mn pig iron. Whether a reduction in costs can be effected by this practice depends, of course, on the cost of scrap, high Mn pig iron, fuel, etc. In Germany at the time the tests were made, the practice with the Mn ore resulted in a 20 per cent saving in the cost of the charge. The subject of the utilization of manganiferous ore in the open-hearth is, of course, closely related to that of Mn reduction from the slag by means of proper slag control.

Open-Hearth Slag Tests

Janitzky[47] showed several years ago that open-hearth slag samples, cast into flat pancake-like molds, have a characteristic appearance, which may give an indication of the composition. This work, by the way, was instrumental in bringing out the relationship between slag basicity and FeO content. An accurate indication of the composition of the slag from its physical appearance would, of course, be of great value, since such a test would be much faster and less expensive than a chemical analysis and could readily be used to control the slag while the melt was still in the furnace. Nevertheless, in spite of the great interest in slag control and in the study of open-hearth slags[48], Janitzky's work does not appear to have been followed up in this country, although such slag tests are reported to be fairly common in Germany.

Back[49] has given a rather detailed description of the appearance of such slag pancakes in relation to the composition, particularly the CaO/SiO_2 ratio. In agreement with Janitzky, he reports that slags with a ratio of about two are shiny black; more acid or more basic slags are duller and mottled. Two series among the many samples Back illustrates are shown in Figs. 24 and 25.

Fig. 25—Appearance of Open-Hearth Slag Tests; More Basic Slags. Back[49]



SLAG NO.		I	II	III	IV	SLAG NO.		I	II	III	IV
CaO consum.	kg/ton	27.8	61.0	67.0	54.0	Per cent oxidation of the finished melt	Kg	312	1200	1270	1200
Finish. slag	Kg	4100	6820	7330	7840			0.542	2.54	2.46	1.98

In Fig. 24 it will be observed that the more acid slags (lower value R = ratio CaO/SiO_2) tend to be white or mottled, but as the basicity increases the slags become smoother and blacker until for a ratio of about two they are smooth, shiny black. Back states that the more wrinkled slags are higher in Mn, and the smoother slags are lower in Mn. A mottled color is also indicative of a higher Mn content. Slags high in SiO_2 give flaky or frosted wrinkled surfaces.

As shown in Fig. 25, the more basic slags become less shiny and more matte in appearance, as the CaO/SiO_2 ratio becomes greater than two. Back states that fluorspar tends to give the slag a matte surface; in a slag with a ratio near two, the shiny black surface reappears soon after the fluorspar addition, but in high CaO slags the matte surface remains. A silvery sheen on the surfaces indicates high FeO; the more pronounced the silver color, the higher the FeO. Samples should not be taken too soon after additions of ore, CaO, sand, or fluorspar.

Obviously, the relations brought out in this study between the appearance and composition of the slag tests are still far from precise, but Back states that the tests prove helpful, particularly when working on a certain grade of steel and after several series of samples have been examined on previous heats. The test is claimed to be an aid to close slag control and would seem to be worth more of a trial than it has thus far received in this country. Such slag tests might perhaps be used to supplement viscosity measurements, such as those with Herty and Christopher's viscosimeter.

Jarring Ingots During Solidification

A patent on jarring ingots was granted as early as 1899, and renewed attempts to do this have periodically been made. One of the aims of jolting is to promote the escape of gases and thus aid in the rimming action; another is to help float inclusions to the top of the ingot; it is also claimed that a finer dendritic solidification structure results in a jolted ingot.

Herzog[50] reports on experiments with jolting ingots now going on at the Aug. Thyssen Works at Duisberg-Hanborn. There 3-ton ingots can be jolted in a machine which raises and lowers the ingots, through a height of about an inch, 4.3 times a second, or less frequently if desired.

So far the results have not been very successful Possibly because of undue violence of the jolting action, this could not be started in either rimming or killed steel until a sufficient skin had frozen over the top to prevent splashing of the molten steel. As a result, a rather large square cavity formed beneath the top skin of the ingot. Undue segregation was also encountered in the zone between the body and skin of the ingot, especially in rimming steel. These features are illustrated in Fig. 26 of killed steel ingots.

In Fig. 26 the large square cavity underneath the solidified top of the ingot is characteristic of these jolted ingots. A considerable amount of dirt was

Fig. 26—Sulphur Prints of Jarred and Unjarred Ingots of Killed Steel. Herzog.[50] Left—Jarred; Right—Not Jarred. Composition of Steel C-0.40; Si 0.28; Mn 0.86 per cent.

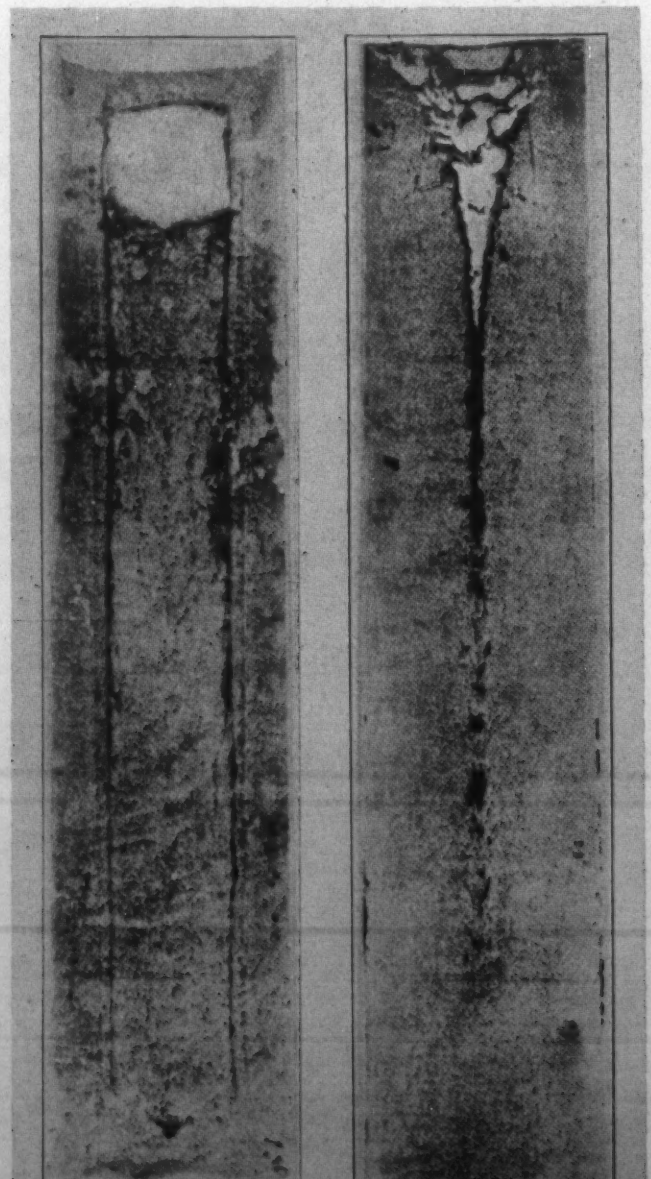


Fig. 27—Jarred and Unjarred Ingot of Rimming Steel. Egler and Tatman.[51] Left, regular ingot; right, jarred ingot. The jarred ingot has a deeper skin, the surface blow-holes being deeper seated. Back

segregated at the base of the cavity so that this portion had to be discarded, and the ingot yield was thus rather low. The segregated zone between the skin and center of the ingot was even more pronounced in rimming steel. Herzog suggested that these difficulties might perhaps be overcome by milder jarring or by vibrating instead of jolting the ingots.

In the United States Egler and Tatman[51] apparently have already overcome the difficulties met by Herzog, for they report even less segregation with jarred rimming ingots than on ordinary rimmed ingots, and, as indicated in Fig. 27, their jarred ingot does not have

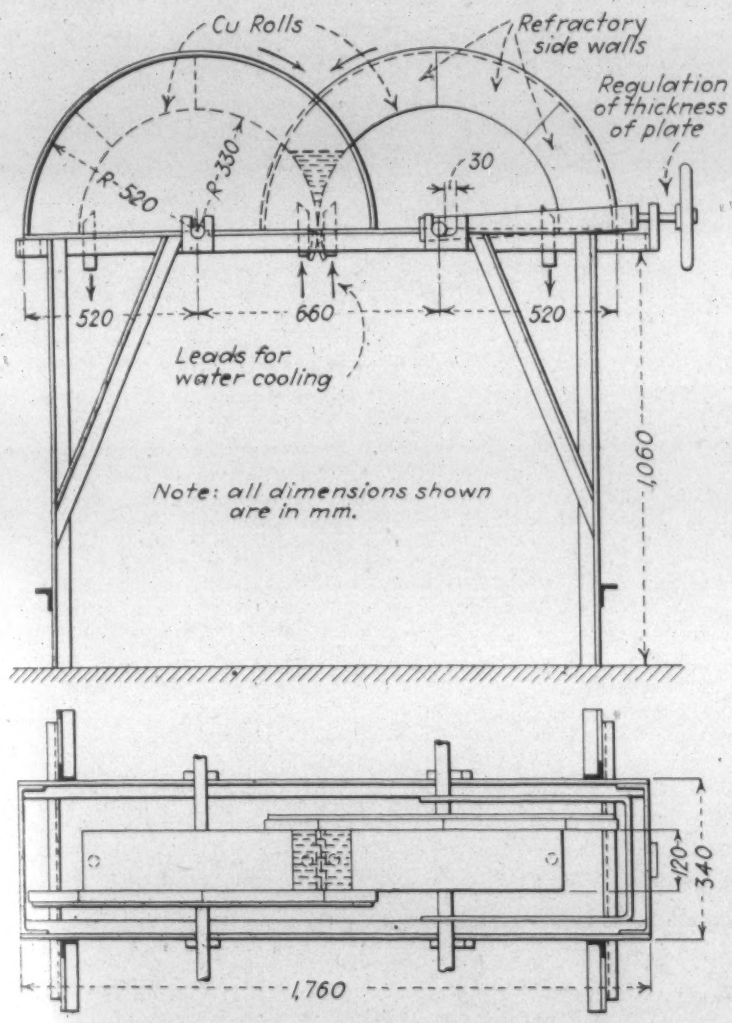


Fig. 28—Apparatus for the Direct Rolling of Molten Steel. Bleckmann[52]

a square cavity at the top; evidently in their jarring machine there is no need to wait until the ingot top freezes over before jarring can be begun.

On jarred rimming steel they report a thicker skin than on unjarred ingots, and, what is very important, they state that jarring so accentuates the rimming action that by this means they have been able to successfully rim steel of up to 0.60 per cent C content, which ordinarily would have to be killed. Henning[17] reports similar results at the Jones & Laughlin Steel Co.

Direct Rolling of Molten Steel

As in the case of the jarring of ingots, the idea of the direct rolling of molten steel is quite old, having been proposed by Bessemer in 1858. Since then various attempts have been made to perfect such a process. These have been summarized by Bleckmann[25], who also gives a description of such a process now being tried out in Germany.

A regulated flow of molten steel is fed between water-cooled copper rolls, the chilled steel being rolled out into plates while still in the mushy state, as illustrated in Fig. 28. What is desired is not simply continuous casting, or rolling a plate solid on the outside but liquid on the inside, but just the right combination of simultaneous casting and rolling. The difficulties are, of course, in regulating the rate of flow of the steel, chill of the rolls, and rolling speed, so that the process can go on continuously, without the molten metal freezing too rapidly, so that it cannot be handled by the rolls, or of the plate getting too thin and breaking down.

These difficulties still remain to be fully overcome. When rolling plates which are too thick with rolls of small diameter, the plates may split apart, as the chilled surfaces may adhere to the strongly curved surfaces of the rolls, because the still liquid interior cannot hold the plate together. The side enclosures have to be made of an insulating refractory to prevent the formation of chilled surfaces perpendicular to the rolling plane. Side walls of fire-clay or silica with smoothed or glazed joints of refractory cement have proved satisfactory, although after each cast it is necessary to dress the rough surfaces.

Bleckmann reports that it was possible to work with rimming steel, as the gases tended to escape through the trough of molten metal above the rolls. Fairly good surface was obtained, and, owing to the rapid chilling, the plates showed an almost total absence of segregation or dendritic structure. This is illustrated by a plate 1½ in. thick.

Lippert[53] reports that experiments with the direct rolling of brass have proved successful in the United States and that fairly large-scale attempts are now being made to roll stainless and other steel directly into sheet.

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From a Drawing by Charles Perry Weimer, New York

The Embrittlement of Boiler Steel*—III

A Correlated Abstract

EVERETT P. PARTRIDGE† and W. C. SCHROEDER‡

Mechanical Properties of Low-Carbon Steel at Boiler Temperatures

WHATEVER PART CHEMICAL ATTACK, as discussed in the preceding sections, may play in the embrittlement of steel, the ultimate failure must be due to mechanical stress. The stress which will produce failure of steel simultaneously subjected to chemical attack might be referred to several different bases. Of these, the tensile properties of the steel at room temperature are the most convenient to measure. However, since steel at boiler temperatures does not behave in the same manner as steel at room temperature, this basis of comparison offers little help toward an understanding of embrittlement failures.

As long ago as 1904, Bach[62] measured the tensile properties of boiler steel at elevated temperatures and emphasized the necessity for designing boilers on the basis of the properties at the actual temperatures of operation. In considering the question of embrittlement, it would seem desirable to adopt this viewpoint. Indeed, any rational interpretation of the combined effects of stress and chemical attack in producing embrittlement at an elevated temperature must be based upon a knowledge of how the steel would behave under stress alone at the same temperature.

* Published by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.) This summary has been prepared in connection with an investigation conducted under a cooperative agreement between the Joint Research Committee on Boiler Feed Water Studies and the United States Bureau of Mines. The general investigation is supervised by a subcommittee of which J. H. Walker is chairman, and is carried out at the Nonmetallic Minerals Experiment Station of the Bureau of Mines, maintained in cooperation with Rutgers University at New Brunswick, N. J. The interpretations and comments in this summary are those of the authors, and the summary as a whole is to be regarded as a report to the subcommittee rather than by the subcommittee.

Preceding parts of this correlated abstract appeared in the June and July, 1935, issues of METALS & ALLOYS.

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Tensile Properties

A number of the earlier high-temperature tensile tests, subsequent to the extensive work of Bach[62], are listed in the bibliography of a paper by White and Clark[63]. The more recent measurements of Körber and Pomp[64] and of Urbanczyk[65] on low-carbon boiler steel are represented in Fig. 7. The curves of the latter are particularly significant because in the range from 390 to 660 deg. F. (200 to 350 deg. C.) tests were made at intervals of 25 deg. C. as compared with the much wider intervals, usually about 100 deg. C., in the case of other investigations. In Fig. 7 the points of Körber and Pomp are simply connected by straight lines which do not represent the probable values at intermediate temperatures. In general, the tensile strength of low-carbon steel passes through a slight minimum between room temperature and 212 deg. F. (100 deg. C.) and then increases markedly to a maximum near 480 deg. F. (250 deg. C) after which it decreases steadily with further increase in temperature. The increase in tensile strength from room temperature to 480 deg. F. varies from 10,000 to more than 15,000 lb. per sq. in.

The effect of temperature upon the yield point is particularly interesting. As the temperature is increased, the yield point, as indicated by the drop of the beam on the testing machine, at first decreases continuously and then at a temperature in the range from 390 to 570 deg. F. (200 to 300 deg. C), disappears entirely.

Continuous creep under stress begins to be significant above 570 deg. F. (300 deg. C.). Körber and Pomp[64] estimated that at this temperature the limiting stress above which creep would be apparent was approximately the same as the yield point. This is shown by the lower group of curves in the upper left quarter of Fig. 7. To the left of the heavy vertical

line at 300 deg. C. the curves represent the yield point, to the right, the limiting creep stress.

The manner in which ordinary low-carbon steel elongates under stress in the boiler temperature range deserves consideration. Instead of a single yield point followed by a continuous deformation such as occurs at room temperature, an autographic stress-strain curve shows a large number of successive yieldings of the steel over the whole range from the first yield

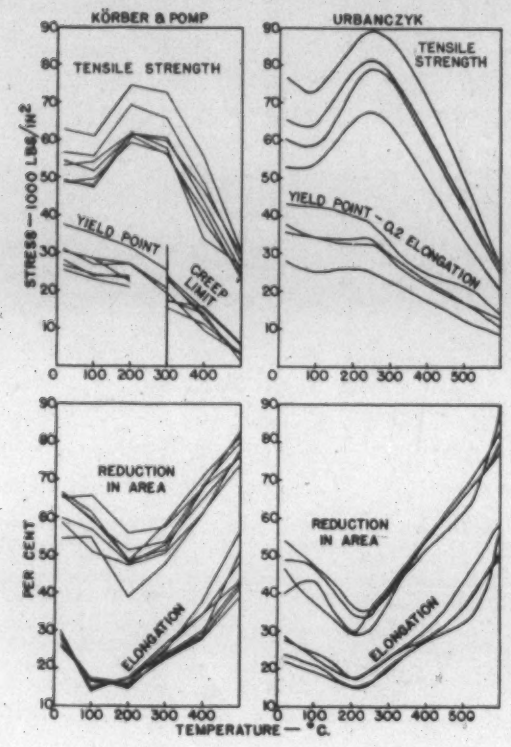


Fig. 7. Tensile Properties of Low-Carbon Boiler Steels.

point to the ultimate fracture. This effect which was observed at as low a temperature as 212 deg. F. (100 deg. C.) by Körber and Pomp[64] and Urbanczyk[65], is very pronounced from 300 to 480 deg. F. (150 to 250 deg. C.) but becomes progressively less noticeable at higher temperatures.

Associated with the increase is tensile strength and the stepwise yielding of steel at boiler temperatures is a corresponding loss in ductility, illustrated by the curves in the lower half of Fig. 7. The elongation decreases with increase in temperature up to about 390 deg. F. (200 deg. C.), and then increases again continuously. The reduction in area shows a similar variation except that the minimum lies at a somewhat higher temperature.

Blue Brittleness and Aging

From the foregoing it is evident that, at temperatures in the boiler range, ordinary low-carbon steel is considerably stronger than at room temperature, but that it is correspondingly more brittle. This "blue brittleness" is believed to be due to an almost instantaneous aging of the steel after overstrain [66, 67]. A piece of steel cold-worked and held at room temperature shows a very slow increase in tensile strength and hardness, combined with a loss in ductility. At the atmospheric boiling point this aging of cold-worked steel takes place much more rapidly, and at still higher temperatures the process is probably extremely fast. For example, Kenyon and Burns[68] quote data from von Köckritz[69] showing that mild steel, cold-stretched 5 per cent and aged at different temperatures, exhibited a maximum increase in tensile strength of 14 per cent. At the shortest time of measurement, 7.5 min., a temperature of 212 deg. F. (100 deg. C.) had caused an increase of 6 per cent in tensile strength, while temperatures of 480 and 660 deg. F. (250 and 350 deg. C.) had caused increases of 13 and 14 per cent respectively. It is probable that at these higher temperatures a very considerable increase in strength had occurred in much less than 7.5 min.

The change in properties referred to as aging is generally attributed to the precipitation of finely dispersed particles of an iron compound from a supersaturated solid solution. A summary of the divergent views concerning the relative importance of carbon, nitrogen and oxygen as the cause of aging has been given by Herty and Daniloff[70]. These investigators found that the embrittling effect of aging after strain, as measured by the Izod impact test, decreased with the degree of deoxidation for steels killed with aluminum. Rimmed, semi-killed, and silicon-killed steels were very susceptible to strain aging, the Izod values at room temperature decreasing 80 per cent or more in many cases. Similar large decreases in resistance to impact as a result of aging after cold work have been found by other investigators. That the temperature at which the impact test is made may affect the results is indicated, however, by the tests of Körber and Pomp[64], who found that aged steels showed considerably higher impact values at 392 deg. F. (200 deg. C.) than at lower temperatures.

That aging is one of the chief factors in causing the failure of riveted seams is boilers has been argued for many years by German writers. It can scarcely be denied that the primary cause of aging, an appreciable strain in the metal, is present around rivet holes. Wölff[71] observed slip with permanent deformation in experimental butt joints riveted with great care. Baumann[72], using refined methods of measurement, made a more detailed study of the strains set up at the rivet holes in steel plates by different riveting pressures and the temperature history of the metal adjacent to the rivets. He concluded that with contemporary machine riveting, the steel for an appreciable area around a rivet hole was stressed above the yield point and heated to a temperature above 572 deg. F. (300 deg. C.). The thermal stress was great enough so that, when a riveting pressure necessary for proper formation of the rivet head was employed, a permanent deformation of the plate was produced.

If Baumann's results represent actual conditions, not only poorly-fabricated boilers subjected to severe drifting, excessive riveting pressures and heavy calking, might be expected to show brittleness due to aging, but also boilers manufactured under the best conditions. Fear of this inherent defect in riveted construction probably played an important part in the successful development and increasing use of the welded boiler drum, which can be annealed to obviate age brittleness[73].

Another result of the attention paid to aging has been the development of "non-aging" steels which show only a slight change in properties when cold-worked and then heated in the boiler temperature range.[74, 75, 76, 77, 78, 64, 70]

Type of Failure

Rosenhain[79, 80] at one time suggested that continuous high stress over a long period of time might produce failure in an amorphous layer of material postulated to exist at the grain boundaries. No failure or evidence of cracking was found, however, when specimens of a 0.1-carbon steel were kept at 572 deg. F. (300 deg. C.) under a load of two-thirds of the ultimate strength for a period of more than 5 yr.[81]. In connection with the preceding discussion, it is interest-

ing to note that these specimens, subjected to prolonged stress, age-hardened to a considerable extent even though the deformation was small.

Intercrystalline cracking has apparently never been observed in steel tested to failure at boiler temperatures in the absence of aqueous solutions. On the other hand this type of cracking seems to be a distinguishing characteristic of many failures in riveted boiler seams. The natural inference is that some factor other than aging alone must participate in causing these boiler failures. Until further knowledge is developed, it might be best to regard aging as a contributory, possibly an important, but probably not an exclusive factor in causing embrittlement failures.

Conclusions

This brief discussion of the properties of low-carbon steel at boiler temperatures and of the part which aging may play in causing the brittle failure of boiler steel will have served its purpose if it brings home the fact that the apparently stable metal of a boiler may actually vary almost as much in its behavior as the water within it varies in composition. A few general statements may be emphasized:

1. The tensile strength of ordinary low-carbon steel is greater and the ductility is less at boiler temperature than at room temperature (See Fig. 7 for representative curves).
2. Any mechanical test of chemical attack upon steel should be considered with respect to the properties of the steel at the test temperature.
3. The increased tensile strength, dcereased ductility, and step-shaped stress-strain curve of ordinary low-carbon steel at boiler temperatures result from the same changes in steel responsible for aging after cold work.
4. Riveted boilers of good as well as of poor construction may show a tendency toward brittleness in the vicinity of the rivet holes as a result of aging, entirely aside from any effect produced by chemical action of the boiler water on the steel.
5. Aging of the steel may be one of several factors contributing to embrittlement failures in boilers.

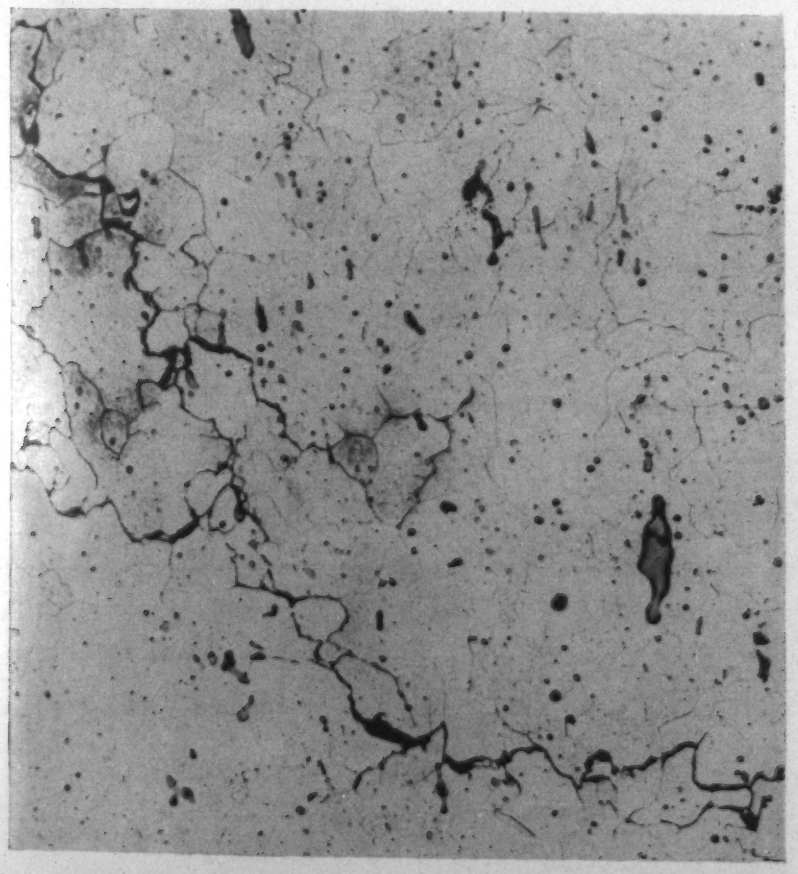


Fig. 8. Intercrystalline Cracks in Steel Tube from Caustic Soda Evaporator. 100 diameters. (White and Schneidewind)

The Cracking of Low-Carbon Steel Under Combined Chemical Attack and Mechanical Stress

IN the preceding sections certain factors which may be important in causing the apparently brittle failure of low-carbon steel have been considered individually. In actual practice, however, the effects of chemical attack, temperature and stress are inevitably intermixed. Evidence concerning the mutual relation of these different variables will now be examined. The qualitative information which can be gained from apparently brittle failures in caustic-soda evaporators and steam boilers will be considered first, and then the more quantitative information from laboratory experiments in which failure has been produced by combined stress and chemical attack.

Embrittlement Failures in Evaporators and Boilers

Certain similarities in the brittle failure of steel in caustic-soda evaporators and in steam boilers have led to the more or less indiscriminate use of the term "caustic embrittlement" to designate boiler failures in which intergranular cracking of the steel was evident. In its broad aspects the relation between the conditions in the two types of equipment may be stated as follows:

Steel exposed to hot concentrated solutions of sodium hydroxide in a caustic-soda evaporator is not subjected to any serious stress as a result of pressure

Fig. 9. Intercrystalline Cracks in Wrought Iron Strap Exposed to Hot Concentrated Trisodium Phosphate Solution. 100 diameters. (White and Schneidewind)

in the apparatus, although due to cold working, poor alignment, or thermal expansion, localized stresses of unknown and possibly large magnitude may exist. In a boiler, on the other hand, the stress due to the pressure of operation must be considered in addition to the unknown stresses, but the concentration of dissolved substances in the body of the boiler water is usually low. The temperature of operation of most boilers is considerably above the highest temperature

attained in a caustic-soda evaporator. With these considerations in mind, reports of brittle cracking, first in evaporators, and then in boilers may be compared.

Failure in Evaporators

Not only evaporators, but dissolving tanks, fusion pots, digesters, and similar plant equipment handling hot solutions of sodium hydroxide are subject to a brittle type of failure. Certain other substances particularly nitrates, seem to produce the same effect.

In general, the failure of low-carbon steel exposed to hot concentrated solutions of sodium hydroxide seems to take place in regions which have been cold-worked or are subjected to thermal or structural stresses. Thomson[82] cited the cracking of boilers used for evaporating caustic soda from 5 to 12 per cent. The cracks occurred along the line of rivets and rivet heads were broken off. Stromeyer[83] made the general statement in 1910 that trouble was experienced with iron tubes in caustic evaporators if the solution exceeded a concentation of about 40 per cent of sodium hydroxide. He reported that tubes cracked where the ends had been expanded into the tube sheets, and that rivet heads snapped off.

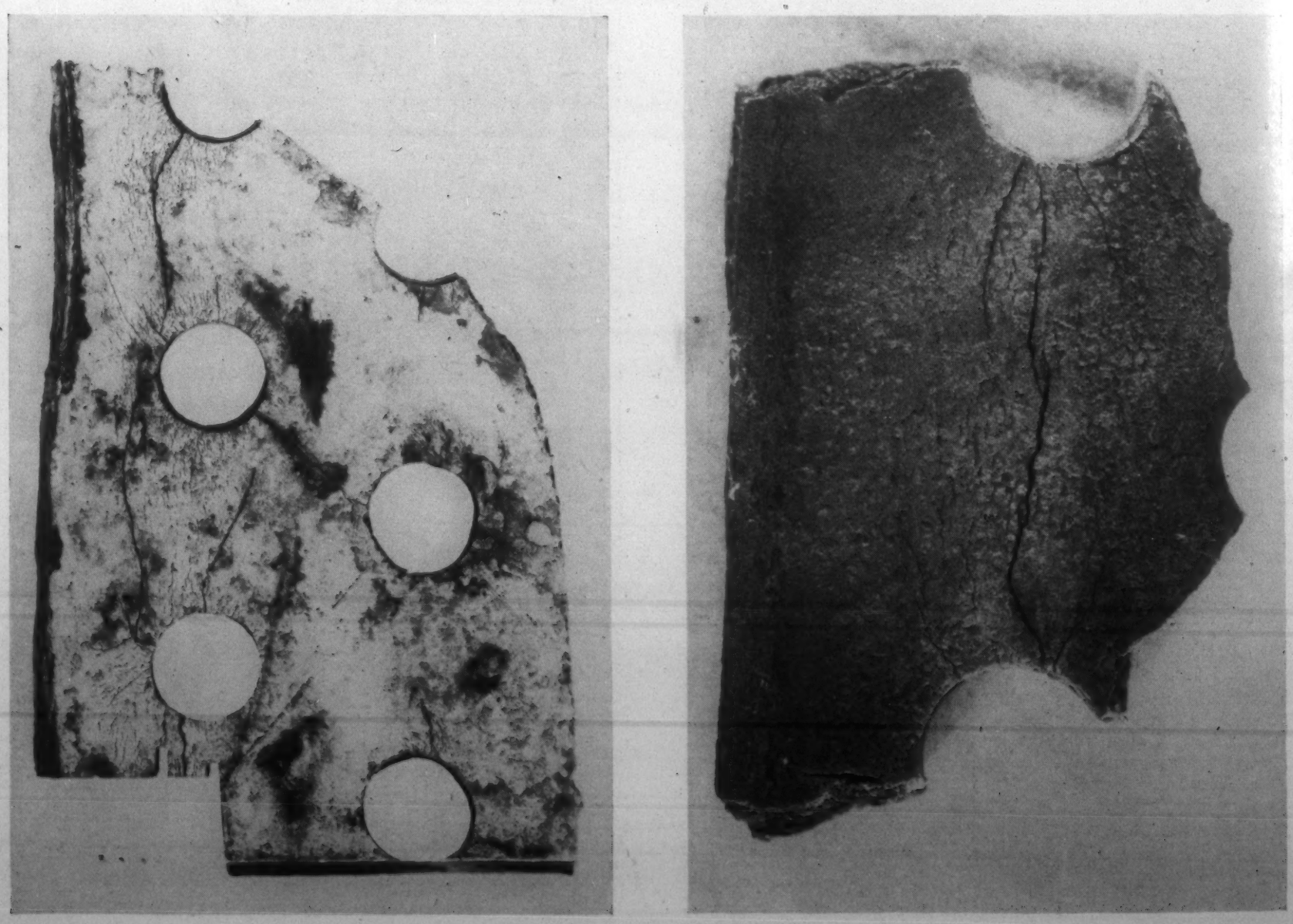
The cracking of expanded tube ends is also mentioned by Andrew[84]. He reported that the fracture was transcrystalline but that the grain boundaries were thicker than usual and the polished surface was covered with a network of unusual markings.

Cracking similar to that encountered in caustic-soda evaporators was found in vats and evaporating pans used in the manufacture of ammonium nitrate, according to Jones[85] who stated that high stress was an essential factor in the failure. Hanson[86] has reported intercrystalline cracking in cold-drawn steel tubing used intermittently for six months in fused nitrates at 570 deg. F. (300 deg. C.). This tubing was under no applied stress but may have been internally stressed as a result of cold work. That internal stresses were an essential factor in the failure was suggested by the fact that similar tubing after annealing or normalizing did not fail.

A number of cases of cracking in apparatus exposed to hot concentrated solutions of sodium hydroxide have been described by Baumann[87], who concluded that the cracking was due to the chemical attack of the hot caustic on the steel, combined with the effects of internal stresses from cold working, of thermal stresses, and of stresses set up by the crystallization of substances from solution in fine cracks in the metal.

Ries[88] ascribed the frequent cracking encountered in caustic-soda cookers to chemical attack upon steel which had been deformed by riveting, boring, drifting, bending, or similar operations. Straub[89] has reported the cracking of riveted seams in digesters operated at 150 lb. pressure with 20 per cent caustic soda solutions and the absence of cracking in companion units in which the caustic concentration during digestion was considerably lower. Evidence of severe cold working was found in both the cracked and uncracked digesters. White and Schneidewind[90] mention the cracking of a low-carbon steel tube from a vertical tube caustic soda evaporator after about one year's service, and also

Fig. 10. Typical Examples of Embrittlement Cracks in Riveted Boiler Seams.



the interesting case of the embrittlement of a wrought-iron strap which failed in the absence of any appreciable load after eight weeks operation in a solution containing 55 per cent of commercial trisodium phosphate at 60 deg. C. (140 deg. F.). Photomicrographs of the intercrystalline cracks observed in these two cases are shown respectively in Figs. 8 and 9.

The testimony from varied sources is in rather good agreement on the following points: The failure of steel exposed to hot concentrated solutions of sodium hydroxide occurs chiefly in portions of the metal subjected to stresses which are unknown but may be rather high. The cracking takes place predominantly along the grain boundaries.

Failure in Boilers

White and Schneidewind[90] have briefly reviewed the subject of fractures in boiler metal and have presented a comprehensive and carefully prepared series of photomicrographs illustrating typical failures of boiler steel. These include examples of compression, bending, impact and fatigue produced in the laboratory, and other examples from operating boilers attributed respectively to aging, corrosion, "caustic embrittlement," and overheating. From a study of these, the authors concluded that bending, compression, tension and impact produce failures which are predominantly through the grain and are accompanied by deformation of the crystals, although in the case of some impact failures the deformation may be slight. Failures resulting from fatigue and from exposure to alkaline liquors both occur without deformation of the grains, but in the former case the cracks are transcrystalline while in the latter they are intercrystalline. These findings substantiate the statements of Straub[91].

In many cases the metal adjacent to the failures in riveted seams and tube ends of steam boilers has shown definitely intercrystalline attack. Since this is characteristic of steel exposed to sodium hydroxide, Parr and Straub[92, 93, 94] drew the reasonable inference that the intercrystalline cracks in boilers must be due to this constituent in the boiler water. They have supported this theory by correlating the occurrence of this type of failure with the use of waters which, either as a result of their original composition or of a process of treatment, caused the development of relatively high alkalinity in the boilers.

The greatest concentration of sodium hydroxide found in a boiler water is, however, very low compared to the concentration usually present in caustic-soda evaporators and other types of equipment which have exhibited intercrystalline cracking This discrepancy has been met by the assumption that concentration of a boiler water might take place in the small spaces of almost capillary dimensions between plates in a riveted seam. Thiel[95] has made some calculations to show that a high degree of concentration is theoretically possible, and Baumann[96], Berl and his co-workers[97], and Straub[98] have performed laboratory experiments in which the concentration of a solution in a capillary space simulating a seam was increased by evaporation to many times that in the adjacent main body of solution. Evidence from the practical standpoint is also quoted by Straub[99] who observed the formation of a snow-like deposit along the juncture of the plate and butt strap in a boiler down for inspection. This

Fig. 11 Cracked Tube End from 125-lb. Boiler.

proved to be sodium carbonate, which was evidently formed by contact of the air with a relatively concentrated solution of sodium hydroxide slowly seeping out from between the plates. Rösing[100] similarly observed, during microscopic examination of sections through riveted plates from boilers, that where the rivets did not fill the holes snugly, concentrated boiler water diffused slowly to the surface producing characteristic salt deposits and rust formations.

The theory that intercrystalline cracking in boilers is due to chemical attack by highly concentrated caustic solutions in the seams has been vigorously criticized by Applebaum[101], who cites several other conditions under which this type of failure has been observed in steel. While the number of actual cases appears to be small compared to the number in which intercry-stalline cracking has been linked definitely with the presence of a highly alkaline solution, a reasonably open mind might be the best attitude until further investigation leads to a more definite answer.

Instead of attributing to sodium hyroxide some specific ability to cause intergranular failure of boiler steel, McAdam[102, 103] regards what is commonly termed "embrittlement" as simply one manifestation of the general phenomenon of stress corrosion. He has advanced the opinion that the intercrystalline failure is due to corrosion pitting which differs from ordinary sharp, deep corrosion pitting chiefly in its location. He states that intercrystalline corrosion should be favored by relatively high stress, low cyclic frequency, slight intensity of general corrosion, and very little accumulation of corrosion products.

Ulrich[104, 105] has expressed the opinion that every riveted boiler sooner or later will develop cracks as a result of the repeated stresses to which it is subjected in service. His examination of the records

of 14 boilers operated at a pressure of 20 atmospheres approximately 300 lb. per sq. in.) showed that after 5 yr. of service 15 per cent showed cracks, and after 10 yr., 70 per cent. Considerably less tendency to develop cracks was indicated by the records of 18 boilers operated at a pressure of 13 atmospheres (approximately 190 lb. per sq. in.)

A few typical cases of intercrystalline cracking of riveted boiler seams [106, 107, 108, 109, 110, 111, 71], and of expanded tube ends [112, 113] have been described in more or less detail, but the published information is rather meagre when considered in the light of Powell's statement [114] that, in the period from 1930 to 1934, embrittlement had been detected in about 60 steam-generating stations in which approximately 175 boilers had shown partial or total failure. Examples of cracked plates are given in Fig. 10, while Fig. 11 shows a cracked tube end.

The salient features of embrittlement failures have been summarized in the 1922 and 1925-1926 reports of the Prime Movers Committee [115, 116], in the 1927 report of Subcommittee 6 of the Joint Research Committee for Boiler Feedwater Studies [117], and in the publications of Parr and Straub [118]. At the risk of unnecessary repetition, a restatement with some modifications will be made here:

1. The failures occur only in parts of the boiler reached by water.
2. They are found only in those regions of the submerged metal particularly subject to high localized stresses, i.e., riveted seams and rolled tube ends.
3. These regions are also the only ones in which the boiler water might conceivably become concentrated above its normal value.
4. The cracking does not commence on the surface of the metal in free contact with the boiler water, but rather where two separate pieces of steel, as a plate and a butt strap, a rivet and a plate, or a tube end and a plate are adjacent to each other.
5. The obvious cracks are extremely irregular; although they generally follow the line of rivets they frequently run past each other; occasionally they start in the solid plate between rivets but more frequently at rivet holes; the microscopically visible cracks are predominantly intercrystalline.
6. There is no elongation of the steel or deformation of individual grains such as is observed when normally ductile metal fails.
7. The failures occur in steel with excellent chemical and physical characteristics as well as in material of poorer grade.

In addition to these statements on which there seems to have been very general agreement, the 1922 report of the Prime Movers Committee [115] contains the following notes which are suggestive of hydrogen embrittlement resulting from chemical attack, as discussed previously in this survey.

> "Brittleness of the material under shock and fatigue, with very little indication of brittleness under static tests, and marked localization of the embrittlement to the joint area.
>
> "Loss of embrittlement (not necessarily total) with time when the boiler is removed from service, coupled with a marked degree of removal of embrittlement by heating at temperatures far below those required for ordinary annealing.
>
> "A plentiful deposit of a black, powdery substance on the affected surface which on analysis is principally an iron oxide."

The original observations which led to these general statements would be of considerable value if they have been preserved.

The discussion of embrittlement in boilers might be extended indefinitely without extracting much additional useful information. Attention will therefore be directed in following installments to laboratory investigations on the failure of boiler steel under combined stress and chemical attack.

(To be continued)

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1. ORE CONCENTRATION

JOHN ATTWOOD, SECTION EDITOR

Principal Gold Recovery Processes. A. W. FAHRENWALD. *Mining Journal*, Arizona, Vol. 19, May 30, 1935, pages 3-6. The principal features of processes for the recovery of Au are reviewed for amalgamation, cyanidation, flotation, gravity concentration and combinations of these processes. Ten flow sheets are given which illustrate the best methods of recovery under various conditions of the ore and the text defines the conditions which affect the choice of a particular flow sheet. WB (1)

Gold and Silver Custom Plants. E. D. GARDNER. *United States Bureau of Mines, Information Circular* No. 6842, May 1935, 4 pages. The Western Au custom mills, their capacities, recoveries, rates, etc. are listed. AHE (1)

1a. Crushing, Grinding & Plant Handling

Further Notes on Power Used in Crushing. JOHN S. OWENS. *Bulletin Institution of Mining & Metallurgy* No. 366, Mar. 1935, 39 pages. Data are given of drop weight crushing of pyrite and quartzite. The best of several formulas developed and tested is $W = C((1/S) - (1/D))$, where W = watt-hours/ton, D = original diameter of the particle, S = distance between hammer and anvil (diameter of particle after crushing) and C = a constant for each ore. The limits to crushing in 1 operation are discussed mathematically. When crushing an isolated piece of ore the limiting value of S is D/7.84; for a group of pieces the limiting value is D/1.7. In rolls a high peripheral speed with a thin stream of feed gives more efficient crushing than a low speed and a thick stream. Jaw crushers and cone crushers, that carry out the process in a number of small stages with intervals when small fragments may escape, are likely to be more efficient in energy consumption than rolling. AHE (1a)

1b. Gravity Concentration

Scheelite: **Its Occurrence and Notes on the Treatment of Ores.** ALAN G. REID. *Journal & Record of Transactions of Junior Institution of Engineers*, Vol. 45, Oct. 1934, pages 38-48; *Crushing, Grinding, Mining & Quarrying Journal*, Vol. 2, Jan.-Feb. 1935, pages 396, 398, 400-402. The ore is concentrated by jigging and tabling. WH + AHE (1b)

1c. Flotation

Problems **in the Flotation of Gold.** R. A. PALLANCH. *Mining & Metallurgy*, Vol. 16, Apr. 1935, pages 177-180. Includes discussion. From a paper presented before the Utah section of the American Institute of Mining Engineers. Gives several examples showing that all Au ores treated by flotation do not respond to a standardized method of treatment. Each ore presents an individual problem. Microscopic examination is becoming of increasing value to determine quality of the ore and method to be used. VSP (1c)

1d. Magnetic Separation

Some **Observations on the Movement and Demagnetization of Ferromagnetic Particles in Alternating Magnetic Fields.** C. W. DAVIS. *Physics*, Vol. 6, June 1935, pages 184-189. The tests on the particles included effect of alternating fields of moderate frequencies and single phase, behavior at high frequencies, moving alternating fields, observation of particle movement and demagnetization by high frequency fields. The practical aspects of demagnetization in the production of superior magnetic concentrates and possible application of high frequency demagnetization to magnetic testing are discussed. For this practical angle a study was made of the conditions of demagnetization in magnetic fields produced by damped, high frequency oscillatory discharges. An apparatus is described consisting of a solenoid with the field established in the center and through which the ore particles are poured whereby sufficient demagnetization of the particles is effected to prevent them from sticking together. The method has been applied to Fe materials that did not respond to usual demagnetizing methods and has for the first time provided magnetic means of separation from waste matter for some of the Fe materials previously treated without success by means of d.c. magnetic separation. WB (1d)

1e. Amalgamation, Cyanidation & Leaching

The Gold Mine of St. Barbara—A Property Placed on a Profitable Basis in Six Months. JOHN L. MIDDLETON. *Engineering & Mining Journal*, Vol. 136, June 1935, pages 279-280. The mine at St. Barbara is located along the Pek River in Yugoslavia. An 80-ton amalgamation plant is to be supplemented by a mill for cyaniding the tailings. Overall recovery is expected to be about 90%. WHB (1e)

A New Process for Oxygenating Solutions. T. K. PRENTICE. *Journal of the Chemical, Metallurgical & Mining Society of South Africa*, Vol. 35, Mar. 1935, pages 285-289. Discussion. See *Metals & Alloys*, Vol. 5, Sept. 1934, page MA 429. AHE (1e)

2. ORE REDUCTION

A. H. EMERY, SECTION EDITOR

Relationship Between Dissociation Vapor Pressure of Sulphides and the Order of Deposition in Ore Deposits (Die Beziehungen zwischen den Dissoziationsdampfdrucken von Sulfiden und ihrer Ausscheidungsfolge auf magmatogenen Erzlagerstätten). ERNST KORDES. *Zeitschrift für Kristallographie, Abt. B, Mineralogische & Petrographische Mitteilungen*, Vol. 46, No. 4, 1935, pages 256-288. Paper before the Deutsche Mineralogische Gesellschaft, Berlin, deals at length, with the dissociation of sulphides of Bi, Hg, As, Sb, Pb, Ag, Fe, Cu, Zn and Mo in relation to temperature and with the effect of excess H_2S, S and H_2O on the reactions. The similiarity of Fournet's series of metals arranged according to their affinity towards S (Cu, Ni, Co, Fe, Sn, Zn, Pb, Ag, Sb, and As) and the rising S tension of sulphides of Cu, Fe, Zn, Sn, Pb, Ag, Sb, and As is pointed out. A special chapter is devoted to the heats of formation of metal sulphides. EF (2)

2a. Non-Ferrous

Preliminary Results of the Operation of the Dnepr Alumina Plant. A. M. FRENKEL. *Legkie Metallui*, Vol. 4, Jan. 1935, pages 4-12. In Russian. Low-grade bauxites after crushing and agglomeration are smelted with coke and limestone in an electric furnace. Fe and Si are reduced to ferro-silicon and the Al enters the slag. This slag, containing 42-48% Al_2O_3, 43-49% CaO, and 5-8% SiO_2, is crushed and leached to extract the Al_2O_3. Precipitation of the Al_2O_3 is accomplished by the addition of CO_2. The plant produces 1250 tons of Al_2O_3 monthly with an SiO_2 content of 0.3%. Difficulty was experienced in the operation of the electric furnace due to the segregation of Ti from the ferro-silicon and the subsequent formation of crusts which had to be periodically removed. Crushing and grinding of the charge proved troublesome due to its abrasiveness. HWR (2a)

Review of the Activity of the Electrolytic Department of the Dnepr Aluminum Plant for 9 Months of 1934. A. I. ZHELEZNOV. *Legkie Metallui*, Vol. 4, Jan. 1935, pages 13-25. In Russian. The use of artificial cryolite with a molecular ratio of NaF to AlF_3 of 2.3-2.7 gave very good results. Alloys of Al with Si were produced successfully by adding silico-aluminum directly to the electrolytic bath. The silico-aluminum for this purpose was obtained by the reduction of kaolin in an electric furnace and contained 77-78% Si, 20-21% Al, and 1-1.5% Fe. Alloys of Al wih Ti or Cu were produced directly by adding TiO_2 or Cu scrap to the bath. Increasing the current density from 1.18 to 1.35 amp./cm.^{2} decreased the efficiency of the bath about 10%, decreased productivity, and made operation difficult due to the high temperature of the electrolyte. Substitution of magnesite lining for graphite lining increased productivity of the bath 2-3%, decreased consumption of raw materials and of electrical energy 2-3%, and made operation more even and easier. HWR (2a)

Cobalt and Its Metallurgy in the Electric Furnace (Le cobalt et sa métallurgie au four électrique). *Journal du Four Électrique*, Vol. 44, Feb. 1935, pages 55-56. Cu ores containing more than 6% Co are melted in 480 KWH arc furnaces; 150 kg. coke or charcoal is added to each ton of ore. Between 1400° and 1500° C. the gangue is melted and the alloy separates in 2 layers, 11-16% Cu, 50-60% Co, 30-35% Fe and 90-93% Cu, 3-5% Co, 3-5% Fe. These layers are treated chemically for their Co. Ores with Co less than 6% are melted in a water jacket, and the Co-containing slag is added to electric furnace charge. At Rhokana the slag is melted in a rocking electric furnace where Co reduces faster than Fe so that alloys with 50-55% Co, 7-9% Cu and 35% Fe are produced. JDG (2a)

Bismuth in Copper: Its Effect, Determination, and Some Experiments in Its Gaseous Elimination. C. O. BANNISTER. *Bulletin of the Institution of Mining & Metallurgy*, No. 364, Jan. 1935, pages 1-29. Discussion. See *Metals & Alloys*, Vol. 6, May 1935, page MA 178R/2. AHE (2a)

Recent Progress and the Economic Situation of Nonferrous Metallurgy. Zinc (Les récents progrès et la situation économique des métallurgies autres que la sidérurgie. Le zinc). LÉON GUILLET & MARCEL FOURMENT. *Revue de Métallurgie*, Vol. 32, Mar. 1935, pages 101-105. In the Hoboken-Robson sintering process 1 part of raw concentrates is used with 5 parts of crushed sinter. An installation at Swansea belonging to the National Smelting Company using 2 Dwight-Lloyd belts is described. Total Zn losses are around 2%. The sinter always contains less than 1% S and is very suitable for distillation on account of its great permeability and the lower temperature required for reduction, about 120° C. Extraction is improved, so that about 2% extra Zn is recovered. Denser sinter increases the capacity of the distillation retorts by 10-25%. JDG (2a)

2b. Ferrous

Some Observations and Theory on Slack-wind Blast-furnace Operation. FRANCIS M. RICH. *Metals Technology*, Apr. 1935, *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 617, 23 pages. Results obtained with low-output operation of several furnaces at different plants are discussed. For proper operation it was found advantageous to determine flow characteristics of gases in upper part of furnace and to correct charging to give proper flow. Thermocouples in the lining are recommended for keeping accurate check on lining. If lining tends to build up, as it frequently does with slow wind, the usual remedy is to upset filling in order to remove the scab. Siliceous materials may be used to clean walls. It is concluded that practically all blast furnace operators were overblowing their furnaces prior to the depression. JLG (2b)

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3. MELTING, REFINING AND CASTING

Some Oxide Reactions and Their Importance in the Silicate Industries and Slag Chemistry (Naagra Oxidreaktioner och Deras Betydelse för Silikatkemisk Industri och Slaggkemi). J. ARVID HEDVALL. *Teknisk Tidskrift* (Section *Kemi*), Vol. 65, June 8, 1935, pages 41-46. A paper presented at the Spring meeting of Swedish Society for Chemistry and Mining, May 24, 1935. Contains a theoretical discussion of sintering and smelting phenomena and the effect of various components, such as the oxides of Fe, Cu, Zn, Al and Co. Also treats the ability of SiO_2 to react in the solid state; reactions between CaO and silicates or spinnels, and between SiO_2 and FeS_2; and the conditions for thermal decomposition of dolomite. BHS (3)

Electric Induction Furnace for Metal Melting (Les Fours Electriques à Induction pour la Fusion des Métaux). J. MINSSIEUX. *Electricité* (*Science et Industrie*), Vol. 17, Apr. 1935, pages 146-148. General discussion of electric furnace practice. FR (3)

Casting under High Pressure (La Fonderie sous Pression élevée). L. JENICEK. *Revue de Fonderie Moderne*, Vol. 19, May 25, 1935, pages 163-164. Brief review of modern machinery used for casting under pressure. 5-20 kg./cm.² are applied for piston pressure, 30-50 kg./cm.² for air pressure. The velocity of casting must be fast enough to fill the mold before the temperature of the metal drops appreciably. Metals and alloys used for pressure casting in different countries and equipment employed are described briefly. Ha (3)

The Manufacture of Drill and Other High Grade Steels at Vereeniging, Transvaal. J. H. DOBSON, G. ROBSON, J. BURNARD BULLOCK & H. CLARKE. *Journal of the Chemical, Metallurgical, & Mining Society of South Africa*, Vol. 35, Nov. 1934, pages 155-157. Discussion. See *Metals & Alloys*, Vol. 5, June 1934, page MA 300. AHE (3)

3a. Non-Ferrous

Production of Tin Solder Bars (Zur Herstellung von Lötzinnstangen). E. T. RICHARDS. *Die Metallbörse*, Vol. 25, Feb. 2, 1935, page 147. Solder bars are sold and bought according to their metallic luster. A 50% Sn solder produced by unskilled labor may look like a 40% Sn solder. Pb tends to discolor the cheaper Sn solders to a marked extent. The prejudices prevailing in the U. S. A. and France against the "contamination" of Sb are groundless. German solders always contain Sb and Sn in the proportion of 3.6 : 54.5. EF (3a)

Modern Die-Casting Machines. E. STEVAN. *Metal Industry*, London, Vol. 45, Oct. 19, 1934, pages 363-365. The author discusses in a general manner the rapid expansion of this modern branch of foundry work. The progressive steps that have been made in the development of the present die-casting machines are listed. It is noted that accepted practice is somewhat different for different alloys. Diagrammatic sketches are used to indicate the operation of a mechanically operated machine and a hand-operated machine with a compressed-air cylinder. HBG (3a)

Contribution to the Electro-Metallurgy of Aluminum (Zur Kenntnis der Elektrometallurgie des Aluminiums). L. TEREBESI. *Helvetia Chimica Acta*, Vol. 18, Feb. 1, 1935, pages 166-178. The reactions occurring during the electrolysis of molten Al oxide mixtures have not been satisfactorily interpreted in spite of the great commercial significance of the process. A historical review of scientific investigations on the underlying reactions and phenomena including the author's own experience (see *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 2 L-1) is given emphasizing the primary reaction in the electro-metallurgical production of Al and the depolarization of the C anodes. Based on the assumption that Al_2O_3 dissolved in cryolite does not conduct the electric current but acts as a solvent, the electrolysis of fused Al_2O_3/Na_3AlF_6 mixtures at 1000° C. is represented by the following sequence of reactions:

(1) Na_3AlF_6 (dissolved in Al_2O_3) $\rightleftarrows$ 2 NaF + AlF_3 (electromotively ineffective)
(2) $AlF_3 \rightleftarrows Al \cdots + 3\ F' \rightleftarrows Al + 3/2\ F_2$ (electromotively effective)
(3) $3\ F_2 + Al_2O_3 \rightleftarrows 2\ AlF_3 + 3/2\ O_2$ (electromotively ineffective)
(4) $C + O_2 \rightleftarrows CO_2$ (electromotively effective)
(5) $CO_2 + C \rightleftarrows 2\ CO$ (electromotively ineffective?)

(4) and (5) only occur with graphite anodes subject to depolarization. With inert Pt anodes the process comes to an end at stage (3). Reaction (5) calls for further investigation. EF (3a)

3b. Ferrous

C. H. HERTY, SECTION EDITOR

Rotary Melting Furnace Practice. S. E. DAWSON. *Foundry Trade Journal*, Vol. 52, Feb. 28, 1935, pages 155-157. Paper read before the East Midlands Branch of the Institute of British Foundrymen. The design and working of the Sesci type of furnace are described. The furnace body consists of a steel shell mounted on 2 tracks, which run on oscillating rollers. The body is lined with a rammed acid lining about 14" thick. At the combustion end of the furnace is fitted a special burner, which is designed for the combustion of anthracite or semi-anthracite fuel. The opposite end of the furnace is connected by a movable head to the flues. According to the author the rotary furnace provides conditions for producing metal, not only free from the effects of contamination associated with cupola practice, but one of a predetermined composition, and of a range hitherto not economically possible. The controlled effect of superheating cast Fe is to produce in the final solid material a pearlite-fine graphite structure. AIK (3b)

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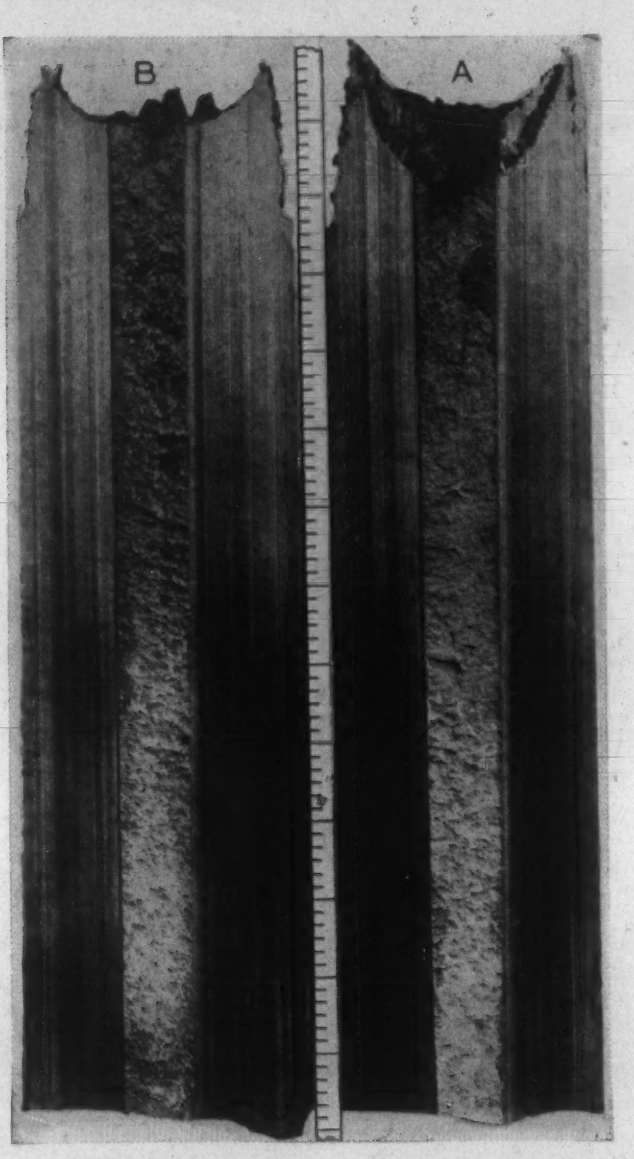

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1 **Heroult Type Arc Furnace in Steel Plants and Foundries (Le Four à Arcs Type Heroult en Aciérie et en Fonderie).** P. GOURDON. *Electricité (Science et Industrie)*, Vol. 19, Apr. 1935, pages 142-144. General article dealing with the following: (a) the furnace, (b) electrical equipment, (c) automatic control of electrodes, (d) basic process, (e) acid process, (f) applications. FR (3b)

2 **Manufacture and Properties of Bessemer Steel.** C. C. HENNING. *Metals Technology*, June 1935, *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 623, 21 pages. Reviews manufacturing methods, operating practice, and certain quality characteristics of Bessemer steel. Typical data showing results obtained by different operations are given. It is stated that the paper was written from the view of bringing out the positive characteristics of the Bessemer process as it was believed that the deficiencies of Bessemer steel were well known and probably often over-emphasized. It is concluded that the further development of the Bessemer process will depend entirely on the amount of technical attention applied. The operating flexibility of the process is considered of great importance. JLG (3b)

3 **The Effect of Carbon as Reducing Agent upon the Reactions of Steel Producing Methods with Acid Slag (Die Wirkung des Kohlenstoffs als Reduktionsmittel auf die Reaktionen der Stahlerzeugungsverfahren mit saurer Schlacke).** F. KÖRBER & W. OELSEN. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf*, Vol. 17, No. 4, 1935, pages 39-61. The course of the 3 principal reactions in producing steel with acid slags between molten C-poor Fe, molten ferrous oxide-manganous oxide silicates and solid SiO_2, namely:

$$Mn + FeO \rightleftarrows MnO + FE$$
$$Si + 2FeO \rightleftarrows SiO_2 + 2Fe$$
$$Si + 2MnO \rightleftarrows SiO_2 + 2Mn,$$

was studied with respect to equilibrium conditions and mutual influences. The reduction of Si by Fe and Mn from liquid silicates and solid SiO_2 takes place fairly quickly up to close to equilibrium while the oxidation of Si even by very liquid, ferrous oxide-rich silicates can be suppressed almost completely due to the formation of a solid film of SiO_2 between Fe melt and slag. The elements Fe, Mn and Si can attain their equilibrium concentrations in the steel melt and in the slag only when the reaction of the C is very slow. If C reacts very actively the equilibrium of Fe, Mn and Si with their oxides in the slag, in the charge and in the melt are distributed and C acts as such a strong reducing agent that the other reactions play only a minor part. The oxidizing effect of the silicate slag on the steel melt is eliminated to a great extent and C reacts with the solid SiO_2 of the sand crucible thus causing the "crucible reaction." The experiments are illustrated by curves. 22 references. Ha (3b)

5 **Mechanism of Reduction of Manganese in Pig Iron Melted in an Electric Tube Furnace.** MIKIO MUKAIYAMA. *Tetsu-to-Hagane*, Vol. 21, Jan. 25, 1935, pages 14-21. In a current of CO, pig irons and slags having different compositions were melted with C in a crucible placed in a Pt-wound tube furnace, and the melts were kept at 1300°-1500° C. for various times, 30-180 min. From the result of chemical analysis of pig irons and slags, it was ascertained that equilibrium could be placed at 2 hrs. after melting. Assuming the formula $MnO + C \rightleftarrows Mn + CO$, the equilibrium constant between the concentration of Mn in pig iron and that of MnO in slag was calculated. The constant increases with rising temperature and decreasing acidity of slag. In Japanese. TS (3b)

6 **Foundry Developments in 1934.** A. L. NORBURY. *Iron & Steel Industry*, Vol. 8, Feb. 1935, pages 171-174. Mechanisation and the principle of mass production have been increasingly applied in prominent British plants. Increased technical control in the foundry has led to tightening up of analytical tolerances of pig and refined irons. CEJ (3b)

7 **Carbon-Molybdenum Cast Steel For Steam Service.** HANS NAEGELI & A. C. JONES. *Journal American Society Naval Engineers*, Vol. 47, May 1935, pages 198-219. Molding problems of high pressure and temperature steam service castings, grade of steel and creep characteristics of C-Mo steels are compared with others. Creep for 10,000 hrs. for .24 C, .49 Mo, 1.1 Mn., .34 Si cast steel is 1.7% at 20,000 lbs./in.², 2.2% at 24,000 lbs./in.² while .27 C, .73 Mn, .35 Si steel creep rate is 25% at 20,000 lbs./in.² Heat treating, welding and inspection of the C-Mo castings are discussed and physical data tabulated for welded material and after heat treatment. WB (3b)

8 **Electric Furnace Iron for Casting or for Remelting.** ALBERT PORTEVIN. *Metal Progress*, Vol. 27, June 1935, pages 66, 68. While high strength Fe may be obtained by alloy addition it may be more economical to produce in an electric furnace an iron with fine graphite in a pearlitic matrix. Appropriate slags may be used in the electric furnace to obtain the purity of Fe required, C can be decreased at will by dilution with steel and still obtain good castability by temperature control and the graphite can be refined by super-heat and proper choice of the nature and time of addition of deoxidizers (Ca-Si or high Fe-Si). WLC (3b)

9 **An Investigation into the Oxidising Power of Basic Slags. Part I.—The Determination of the Binary Diagram CaO-Fe_2O_3. Part II.—The Determination of the Dissociation Pressures of Fe_2O_3, CaO-Fe_2O_3, and $2CaO$-Fe_2O_3.** J. WHITE, R. GRAHAM & R. HAY. *Iron & Steel Institute*, May 1935, Advance Copy No. 9, 21 pages. In the system Fe_2O_3-CaO only 2 compounds, monocalcium ferrite and dicalcium ferrite, were found. Optical properties of these compounds were determined. At the Fe_2O_3 end of the system the diagram is really of a pseudo-binary nature because of the dissociation of excess Fe_2O_3 at high temperatures. The m. p. of Fe_2O_3 was determined as 1595 °C., but this is low owing to the presence of FeO resulting from dissociation. The dissociation pressure of Fe_2O_3 was investigated. It was found to be appreciable at 1100 °C., and to increase rapidly with temperature, reaching approximately 5×10^5 atm. at the m. p. Evidence was obtained that Fe_3O_4 is partly soluble in Fe_2O_3 and that Fe_2O_3 is partly soluble in Fe_3O_4. The Fe_2O_3-Fe_3O_4 diagram is outlined. The dissociation of the 2 calcium ferrites was investigated. Below the peritectic temperatures of these compound O pressure was infinitesimal and at higher temperatures the pressure was probably due to the dissociation of Fe_2O_3 resulting from the peritectic reactions. O pressure of ferrites falls rapidly as FeO increases. CaO has a marked stabilizing effect upon Fe_2O_3. Dicalcium ferrite is probably the compound important in open-hearth slags. 8 references. JLG (3b)

Pipes (Le Soffiature). *Industria Meccanica*, Vol. 17, Apr. 1935, pages 324-330. Formation of pipes in ingots or castings due to faulty molds, arrangements of gates and risers and pouring methods are discussed and correctly made molds illustrated. Ha (3b)

Innovations in Open-Hearth Technique. *Iron Age*, Vol. 135, Apr. 18, 1935, pages 24-30. From meetings of Open-Hearth Committee of the Am. Inst. of Mining & Metallurgical Engineers. Some of the topics discussed were: Sealing furnaces from end to end; widening and lengthening hearths; adopting new checker designs; introducing automatic controls; and modernizing or eliminating troublesome and costly valves. VSP (3b)

Castings Molded After the Safety Pattern. IRVIN A. BRINKMAN. *Steel*, Vol. 96, June 17, 1935, pages 35-36, 38. Describes safety methods used in heavy foundry departments of Mackintosh-Hemphill Co. MS (3b)

Calculation of the Metal Charges for the Foundry Cupola. H. L. CAMPBELL. *Metals & Alloys*, Vol. 6, May 1935, pages 107-112. Discusses the selection of raw materials and the calculation of metal charge composition. Typical problems are worked out and the use of graphs to simplify such calculations is described. WLC (3b)

Advocates Round Grain Sand. D. D. CAMERON. *Foundry*, Vol. 63, Apr. 1935, pages 31, 62. Abstract of paper read before the Pittsburgh Foundrymen's Association, Mar. 18, 1935. Discusses causes of porosity and other defects in steel castings, and stresses value of round grain sand which insures higher permeability than angular grains. Higher permeability permits hard ramming and therefore castings true to shape and weight. Green sand may also be used to advantage where it is necessary to dry the molds. VSP (3b)

Specializes in Alloy Steel Castings. PAT DWYER. *Foundry*, Vol. 63, Mar. 1935, pages 18-20, 59. Describes equipment and methods of procedure at the plant of Chicago Foundry Co. Castings are made in wide range of compositions including plain C and various alloy steels. The company has developed 2 special alloy steels, one to resist high temperatures and the other to resist wear, shock and abrasion. VSP (3b)

Holds Cores to Close Tolerances. PAT DWYER. *Foundry*, Vol. 63, Jan. 1935, pages 28-30, 60, 62. Describes method used in core dept. of the Chevrolet Motor Co. foundry at Saginaw, Mich. VSP (3b)

A Special Application of the "Monell Process" for Steel Making in a Stationary Basic Open Hearth Furnace. A. E. DOBNER. *Journal Chemical, Metallurgical & Mining Society of South Africa*, Vol. 35, Feb. 1935, pages 253-265. A heat using 75-100% hot metal generally is called a "Monell heat"; when less than 75% hot metal is used, it is known as a "Trade heat." The latter is discussed in detail. The average charge for 9 heats was limestone 5.9%, fine Fe ore 8.5%, cold pig metal (amount included in hot metal and amounting to about 25% of the hot metal), and scrap 48%. The order of charging (as above) is highly important. The solid charge is heated about 2 hours until the metal begins to sweat. Hot metal (52%, including cold pig) is poured into the furnace and a very lively reaction begins. Si, P, and Mn in the hot metal rapidly oxidize and form a slag with FeO. This first slag is about 40% of the total slag formed. The limestone is decomposed when the ore reaction is almost over. CO_2 evolution is lively. The "lime boil" is followed by a working period when Fe ore is added to hasten oxidation of C and reduce C in metal from 0.90-1.0 to 0.1%. AHE (3b)

Green Sand for Steel Casting. WM. ROSE. *Foundry*, Vol. 63, Mar. 1935, pages 24-25, 60. Green sand properly prepared is practically impervious to erosive action of steel when poured tangentially. Steel cast in green sand molds is free from internal strains. For that reason many castings made in green sand need not be annealed. Most favorable sand to use is a washed, graded, round, purchased in dry state and screened. Green sand improves in resistance to action of hot metal. Mn steel castings and castings up to 15 tons can be successfully poured in green sand molds. VSP (3b)

Ladle and Teeming Practice in the Open-hearth Department. G. D. TRANTER. *Metals Technology*, Apr. 1935, *American Institute Mining & Metallurgical Engineers, Technical Publication* No. 618, 10 pages. The importance of good pit practice in the open-hearth is emphasized and some of the important details to observe are discussed. Details of several operations at one plant are described. These include ladle bricks, stopper-rod assembly, nozzles, ladle design, molds, teeming, capping ingots and pulling heats. JLG (3b)

Eliminating Surface Defects. R. V. WALLACE. *Blast Furnace & Steel Plant*, Vol. 23, Apr. 1935, pages 251-252, 278-279. Surface defects on blooms and billets can often be traced to poor condition of the interior surfaces of ingot-molds. Expense of chipping may outweigh economic advantage of obtaining maximum service from molds. Another cause of scabs is splashing of steel in pouring ingots. MS (3b)

The Effect of Deoxidation on Grain Size and Grain Growth in Plain Carbon Steels. C. H. HERTY, JR., D. L. MCBRIDE & S. O. HOUGH. *Carnegie Institute of Technology & Mining & Metallurgical Advisory Boards, Cooperative Bulletin* No. 65, 1934, 56 pages; *Heat Treating & Forging*, Vol 20, Nov. 1934, pages 546-552. See extended abstract, *Metals & Alloys*, Vol. 6, Mar. 1935, pages 71-77. AHE + MS (3b)

The Control of Iron Oxide in the Open Hearth. E. H. HOLLENBACK. *Industrial Heating*, Vol. 2, Apr. 1935, pages 201-202. **Controlled Iron Oxide Slags Increase Furnace Yields.** *Steel*, Vol. 96, Feb. 25, 1935, page 42. Discussion presented at a session of the 8th open meeting of the Metallurgical Advisory Board to Carnegie Institute of Technology. Investigation of open-hearth slag control indicated that a basic slag is composed of 2 parts CaO to 1 SiO_2. Other oxides do not affect active basicity of slag. Excess CaO over that required to combine with SiO_2 reduces S from bath. MgO is undesirable in a basic slag. To hold P in slag, Fe_2O_3 content must be increased to point where P_2O_5 is combined as $FePO_4$. CaO is important chiefly because it is most active agent in obtaining high Fe_2O_3 content. This form of control has reduced S and P off-grades materially. MS + Ha (3b)

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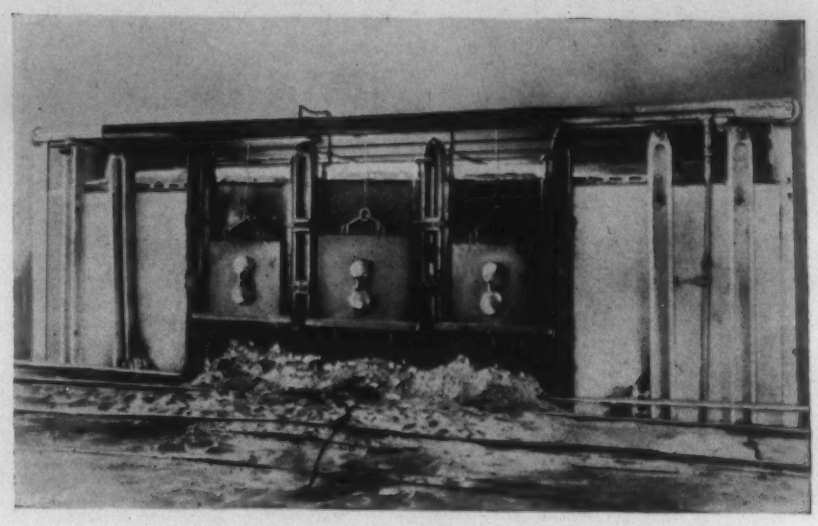

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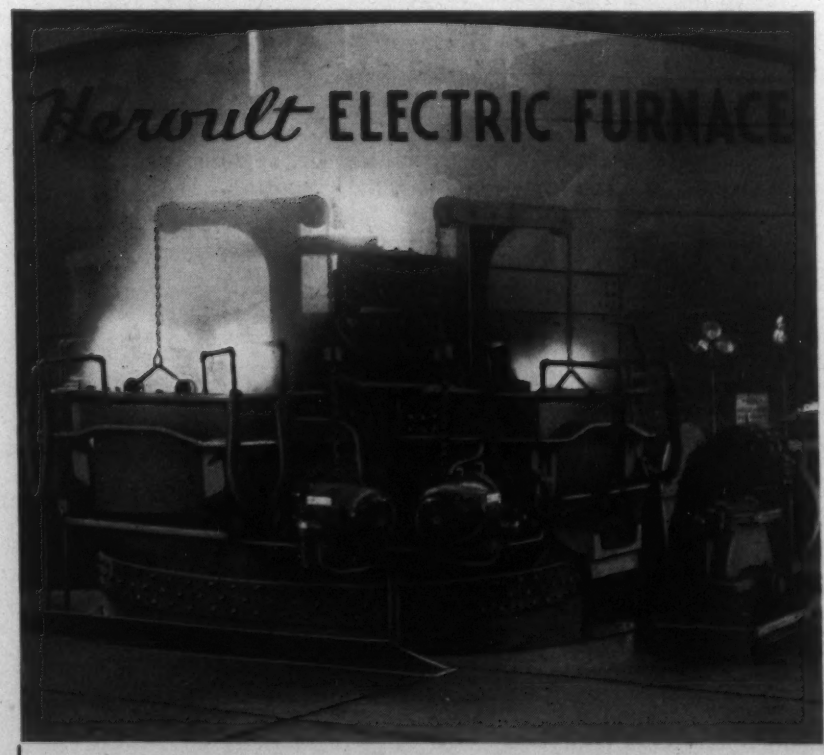

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4. WORKING

The Manufacture and Uses of Metal Powders. J. C. CHASTON. *Metal Treatment*, Vol. 1, Spring 1935, pages 3-10, 12. A systematic account of 16 methods of making metal powders. From solid metals, powders may be made by transcrystalline fracture by tearing or machining (milled Mg powder, Bessemer bronze powder, and sieved foil processes) or by repeated working (in stamp and eddy mills). Fracture on a cleavage plane is utilized in powdering Sb and Bi. Intercrystalline fracture is employed in making powdered iron for loading coils from cathodes deposited so as to be brittle and fine grained, and in making Ni-Fe powder from a brittle alloy hot rolled to a fine grain size. Liquid metals are granulated by a steam jet and metal vapors (Zn and Mg) may be precipitated as powders. Many solid compounds give metal powders when heated in a reducing gas (W, Mo, Fe, Co). From solutions of their salts, metals may be precipitated as powders by replacement (Sn by Zn) or by electrodeposition at high current density (Cu). Gaseous compounds are decomposed in a hot free space, away from the container walls, in the carbonyl process to give Fe, Ni, Co, and their alloys as powders. By pressing and sintering powders, a solid product is obtainable. This process is especially valuable in making metals and alloys which cannot be successfully melted. The purity of the products is often claimed to be high, but oxide inclusions and adsorbed gases must not be overlooked. 21 references.
JCC (4)

4a. Rolling

RICHARD RIMBACH, SECTION EDITOR

The Manufacture and Repair of Locomotive Boiler Tubes. G. H. H. COLLINS. *Journal Institution of Locomotive Engineers*, Vol. 24, Nov.-Dec. 1934, pages 748-784. Includes discussion. A good general account. The first operation of piercing the billet is generally carried out by passing it between inclined conical rolls (Mannesmann process) or, more rarely, coned discs (Stiefel process). Stresses are thus set up in the billet which cause it to burst. The pierced blooms are then rolled in a Pilger mill. Larger tubes are made by piercing the billet to a "bottle" in a hydraulic press, drawing this down by the Ehrhardt or Wellman bush bench process, and then rolling in a Duo or Quarto continuous mill. The final operation consists of cold drawing in a hydraulic push or chain draw bench, with or without mandrels. Annealing, forming the ends of boiler tubes, standardisation, and repair practices are discussed. JCC (4a)

Effect of Roll Diameter in the Rolling of Sheets. W. TRINKS. *Blast Furnace & Steel Plant*, Vol. 23, June 1935, pages 415, 430. Generally, in rolling heavy packs of sheets, increase of roll diam. reduces crown, because stiffness of roll grows faster than separating force. In rolling thin packs, increase of roll diam. increases crown, as separating force grows faster than roll stiffness. It is difficult to avoid type of crown, wherein only edges are thinner than uniform thickness of rest of sheet. Center of sheet is elongated by compression only, while edges are elongated by tension. It can be avoided by shaping rolls, but doing so interferes with rolling different widths on same set of rolls. MS (4a)

The Manufacture of Tinplate. GEORGE A. V. RUSSELL. *Sheet Metal Industries* Vol. 9, Feb. 1935, pages 69-70, 76. Extract from *Iron & Coal Trades Review*. See *Metals & Alloys*, Vol. 6, Apr. 1935, page MA 142. AWM (4a)

Sheet and Tube's Strip Mill in Operation. CHARLES LONGENECKER. *Blast Furnace & Steel Plant*, Vol. 23, June 1935, pages 399-402. Describes new broad strip mill of Youngstown Sheet & Tube Company, Youngstown, O. MS (4a)

Flexibility and Accuracy Stressed in New 79-in. Continuous Strip Mill. *Iron Age*, Vol. 135, Apr. 25, 1935, pages 33A-33C. Describes a new rolling mill of the Youngstown Sheet & Tube Co., Campbell works, erected in record time of 9 months. The mill is capable of rolling steel 18 to 72 in. in width and from 19 gage to ½ in. in thickness. VSP (4a)

Cold Rolling Processes. J. SELWYN CASWELL. *Blast Furnace & Steel Plant*, Vol. 23, May 1935, page 335. Abstract of paper read before the South Wales Institute of Engineers, Nov. 1934. See "Variation of Substances in Tinplate," *Metals & Alloys*, Vol. 5, Oct. 1934, page MA 474. MS (4a)

The Deflection of the Rolls in Plate, Sheet and Strip Mills. J. SELWYN CASWELL. *Iron & Steel Institute*, May 1935, Advance Copy No. 3, 10 pages. Relationship between rolling loads and roll deflections is discussed and the importance of deflection in accurate rolling is emphasized. In calculating approximate roll deflections consideration is given to the combined effect of longitudinal flexural stresses and shear stresses. Limitations of the ordinary bending theory are discussed, and reference is made to recent photoelastic investigations on the bending of beams having roll proportions, i.e., a small value of the span/depth ratio. Equations are derived for calculating approximate values of roll deflection at the center of a roll and at points removed from the middle. The equations are applied to a particular case to find the order of magnitude of roll deflection. Results are compared to some mill observations in which the profile of a sheet removed from a stalled mill was determined. 4 references. JLG (4a)

Production of Blackplate. J. SELWYN CASWELL. *Blast Furnace & Steel Plant*, Vol. 23, Feb. 1935, pages 121-123; Mar. 1935, pages 193-196; Apr. 1935, pages 253-256; May 1935, pages 317-318, 324. Apparently from a paper read before Swansea Technical College Metallurgical Society, Feb. 24, 1934. Discusses some problems encountered in rolling tin-plate with relation to accuracy and uniformity of gage. Among points considered are elastic changes due to stretch of standards and deflection of rolls; roll "sweep"; roll face compression; resistance of rolled stock to deformation; disposal of energy supplied to mill; character of deformation of material; rolling of beveled tin bar multiples; conditions along contact arcs of "bite"; temperature variation through material; roll face friction; roll roughness; pack rolling; and through pack and oversheet variations. MS (4a)

4c. Cold Working, including Shearing, Punching, Drawing & Stamping

Cold Deformation in Boiler Making (L'écrouissage en chaudronnerie) N. DEWULF. *Revue de Métallurgie*, Vol. 32, May 1935, pages 215-224. Series of tests on commercial boiler plate to determine the influence of cold deformation on physical properties. Stressing it 3% by tension renders the steel brittle without affecting its structure and but slightly affecting its strength. Aging intensifies the results. Heating 10 min. at 600°-650°C. eliminates brittleness, but does not restore physical properties. Stressing 6 and 10% produces similar results but for the removal of brittleness heating to 700°C. is required. Stressing specimens by bending 3, 6 and 10% showed that the resistance to static bending of the specimens so stressed and notched was identical to the resistance of specimens which were not stretched at all. Brittleness was produced in all cases. Its elimination required a 10-minute heating at 600°C. for a 3% deformed sample and a 700°C. heating for samples which have been subjected to a greater deformation. Compressing specimens 3, 6 and 10% introduced the same brittleness which could be corrected by heating for 10 minutes at 650° and 700°C. respectively. JDG (4c)

Studies of the Wire-Drawing Process. Part VII. The Application of Metallic Coatings as Lubricants, with special Reference to the Drawing and Properties of a Lead-coated Austenitic Chromium-nickel Steel. E. L. FRANCIS. *Carnegie Scholarship Memoirs, Iron & Steel Institute*, Vol. 23, 1934, pages 46-63. Wire having a Pb coating (applied by the Dudzeele method) facilitates the formation of a stable soap film, which allows greater reductions to be made under normal work conditions. The friction during drawing is rather greater when a Pb coating is used. That there should be a breakdown in the lubrication using soap films alone is not clear to the authors. It is believed however that the Pb plus the soap film gives a thicker and stronger lubricating film. Over a wide range of reductions the Pb coating does not influence the mechanical properties appreciably. Very heavily reduced coated wires show a remarkable combination of high tensile strength and high ductility. The authors point out that there is some parallelism between the work-hardening capacity of a metal, as measured by Meyer's exponent, n, and its resistance to torsional stresses. The alloy tested contained 15.7 % Cr and 10.2 % Ni. Tungsten-carbide dies having a semi-angle of 5½° were used. The rate of draw was 30 ft./min. 8 references. CW (4c)

Effect of Previous Deformation on the Yield Point of Tough-Plastic Materials (Der Einfluss der Verformung auf die Fliessbedingung zähplastischer Körper). W. PRAGER. *Zeitschrift für angewandte Mathematik & Mechanik*, Vol. 15, Feb. 1935, pages 76-80. Mathematical treatment of the theory of plasticity intentionally simplified experimental evidence by neglecting the effect of plastic deformation on yield point. A simple formula is derived which takes the latter effect into account and qualitatively expresses the observed effect of deformation on yield point. In the mathematical derivation, the elastic deformation has been considered as negligible in comparison with the plastic deformation and the material was considered as incompressible. The effect of strain hardening is discussed mathematically. Whereas strain hardening does not upset the isotropy of the material under stress the 2 effects of deformation on the yield point to do so. The third effect, known as the Bauschinger effect, is also dealt with mathematically. WH (4c)

Drawing Wire Shapes. R. SAXTON. *Wire & Wire Products*, Vol. 10, June 1935, pages 227-229. Drawing of different shapes in various kinds of steels, their purpose, arrangement of dies and pressure to assure uniformity of stresses in the drawn material, is discussed. Ha (4c)

Cold Rolled Steel Effects Design Economies. HAROLD B. VEITH. *Machine Design*, Vol. 7, Apr. 1935, pages 31-32, 52. A voting machine which comprises about 17,000 parts practically all of which could be made from steel in the form of cold rolled sheet, strip, bars, bands and flat wire is fully dealt with. WH (4c)

Possibilities in Metal Spinning. *Mill & Factory*, Vol. 16, Mar. 1935, pages 49-51, 120. Forming and drawing processes have limited the scope of spinning but not superseded its usefulness particularly if production quantities are limited and costs of dies prohibitive. Spinning is still widely utilized for experimental work, sample and model making, unusual parts and shapes. Parts which are now made by spinning are washing machine tubes and parts, vacuum cleaner parts, portable electric tools, kitchen utensils, candy machinery, musical instruments, filter shells, machine guards, dental and scientific instruments. Common spinning and trimming operations in the production of drawn and spun metalware are shown in 9 illustrations and discussed in detail. The more rapidly strain-hardening metals and alloys require intermediary annealings. Cold rolled Cu, brass, Al and deep-drawing press steels spin very well. Zn can be spun but gums under the forming tool and if plated, flakes off. German silver presents more difficulties if the Ni content is over 15%. The cheaper steels are suitable only for single operations without deep draws. WH (4c)

Aluminium Sheet Metal Working. *Engineer*, Vol. 159, Apr. 26, 1935, page 448. Describes panel heating, panel wheeling, panel pressing, press working and spinning of Al. In panel heating same machinery and methods are used as for steel. Al is easier to work because of its malleability. Care must be used because of softness of metal, as unless struck squarely with hammer ridges will be formed. In panel wheeling pressure must be governed by thickness and temper of sheet. Due to its ductility, shapes which are too complicated to be made commercially in other metals may be easily obtained with Al. In spinning a peripheral speed of 3000 linear ft./min. is used. Blanks are well lubricated. Fe or Al alloy chucks are used for articles of a permanent nature. VSP (4c)

Spinning Sheet Metals. W. B. Francis. *Metal Industry*, N. Y., Vol. 33, May 1935, pages 155-158. Spinning refers to the process of forming hollow sheet metal shapes by applying pressure against one side of a rapidly revolving disc. The principles of spinning are illustrated by means of figures. The metal must be in its softest condition. Pewter, Al, soft Cu, brass, stainless steel, Mg or Dow metal, low carbon sheet steel, Sn, Be-Cu are mentioned and annealing conditions given. PRK (4c)

Carbide Dies Contribute to Better Wire Drawing. James R. Longwell. *Steel*, Vol. 96, Jan. 28, 1935, pages 22-24, 42. Use of W carbide dies for wire drawing has reduced tolerances on wire size, and decreased cost of production from rod because of the larger yield obtained with a more uniform quality of product. As torsional strength is practically the same throughout bundle, spring maker obtains a more uniform and economical product than hitherto, which has been further improved by using carbide wire guides, pitch tools, and coiling arbors. Cu wire can be drawn with square and some rectangular sections in one pass from the round. In making bolts, less clearance can be used in header and trimmer dies, increasing die life and machine-hr. production, and giving better finish on shank. Carbide dies may be used to extrude thread end, to size bolts which previously were ground, and to burnish flats of nuts, bring their corners up to a sharp edge, and hold the dimension across the flats within close limits. Cooling of dies improves results obtained in drawing. Installation of spring bumper to relieve sudden impact load on die, permits use of smaller, lesss costly dies. With carbide dies, amount of sull coat has been reduced and die used to clean wire. Much thought is being given to hot drawing of wire. MS (4c)

Behavior of Automotive Steels in Turning (Verhalten von Kraftwagen-Baustählen beim Drehen). W. Leyensetter. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Apr. 27, 1935, pages 517-518. 22 American and German automotive steels were subjected to tests to determine the resistance to turning by measuring that time or length of material turned which a cutter of definite composition will stand. A table shows composition of steels, Brinell hardness, cutting velocities obtained. The American steels were found slightly superior to the German steels. Ha (4c)

Influence of Cold-Working on Heat-Conductivity (Der Einfluss der Kaltbearbeitung auf das Wärmeleitvermögen). G. Tammann & W. Boehme. *Annalen der Physik*, Series 5, Vol. 22, Apr. 1935, pages 500-506. Experiments have shown that cold-working reduces thermal and electric conductivity to the same degree expressed in %, and that both properties recover from cold-working within the same temperature interval. Ha (4c)

Gold Foil and Its Production (Über Blattgold und Goldschlägerei). Th. Wolff. *Die Metallbörse*, Vol. 25, Jan. 26, 1935, pages 114-115; Feb. 2, 1935, pages 146-147; Feb. 9, 1935, page 178. The various commercial uses of Au foil are reviewed. Au has by far the greatest ductility of all metals. One g. of Au yields 5000 cm.² of Au foil are reviewed. One g. of Au yields 5000 cm² of Au foil which has the greatest atmospheric stability if chemically pure, although Au with 2-4% Ag, Cu or both is also utilized. The effect of various additions on the color of Au foil is discussed. Translucent light appears to be greenish, bluish, red and gray through Au, Ag, Cu and Pt respectively. Au foil is still being made as it was a thousand years ago although machinery is now used in the preparatory stages of the process. The successive steps in the production of Au foil are: casting into rods, rolling into strips of 1/50 mm. thickness with intermediary annealing and pickling, cutting into 25x25 mm. squares, packing of 500 foils with intermediary layers of parchment, hammering to 1/1000 mm. foil, quartering and assembling of 1000-1200 foils separated by layers of Au beater skin. A polished anvil of granite is used and several hours' hand work stretches the Au foil into a thickness of 1/10,000 mm. which size cannot be imitated by machine operations so far. The final thickness could be reduced further. However the rapidly increasing number of ruptures spoil many foils which at this stage of the operation represent a substantial investment due to the extensive and expensive hand work. Commercial Ag foil is only 1/4,500 mm. thick. Pt foil is relatively cheap since it involves less manual labor. Brass foil, commercially known as "Rauschgold," is 1/1000 mm. thick. It is utilized in place of pure Au foil. Carl Müller, a physicist of the Physikalische Reichsanstalt Berlin, recently developed an electrolytic process which surpasses the traditional mechanical production of Au foil. The thickness of the new foils is only 1/100,000 mm. They are not translucent but transparent like glass. The latter has not found commercial use but is widely used for scientific experiments. EF (4c)

Cold-Pressing and Drawing. I. A Research into Mechanical Tests for Materials Used. H. J. Gough. **II. From the Metallurgical Aspect.** C. H. Desch. **III. New Researches on the Drawing of Cylindrical Shells.** G. Sachs. *Iron & Coal Trades Review*, Vol. 130, Mar. 15, 1935, page 452. Includes discussion at meeting of several (British) engineering and chemical societies. Metallurgical requirements of materials employed and operating processes are discussed. Ha (4c)

Punch and Die Steels. H. R. LeGrand. *American Machinist*, Vol. 79, Apr. 10, 1935, pages 293-296. Compositions of steels to be used for certain kinds of tools, punches and dies are tabulated as they have been standardized in the practice of 2 large manufacturing plants. Ha (4c)

4d. Machining

H. W. GRAHAM, SECTION EDITOR

Finishing Methods for Cylinders and Their Effect on Breaking-in and Service of Motors (Die Verfahren der Zylinderbearbeitung und ihre Auswirkung beim Einlaufen und im Betrieb des Motors). Harry Shaw. *Deutsche Motorzeitschrift*, Vol. 12, May 1935, pages 94-98. The author describes his optical instrument, the "Contorograph," for measuring surface roughness of finished automobile cylinders. Elevations of 1/20,000 mm. are registered by the apparatus, diagrams of which are reproduced. The effect of surface finish on the cylinder wear is discussed at great length. Based on extensive research work, the author recommends fine boring (or grinding) for producing geometrically perfect cylinders followed by honing in order to obtain a most suitable surface finish. The "micromatic" mirror-finish-honing has a surface roughness of only 0.75 μ. WH (4d)

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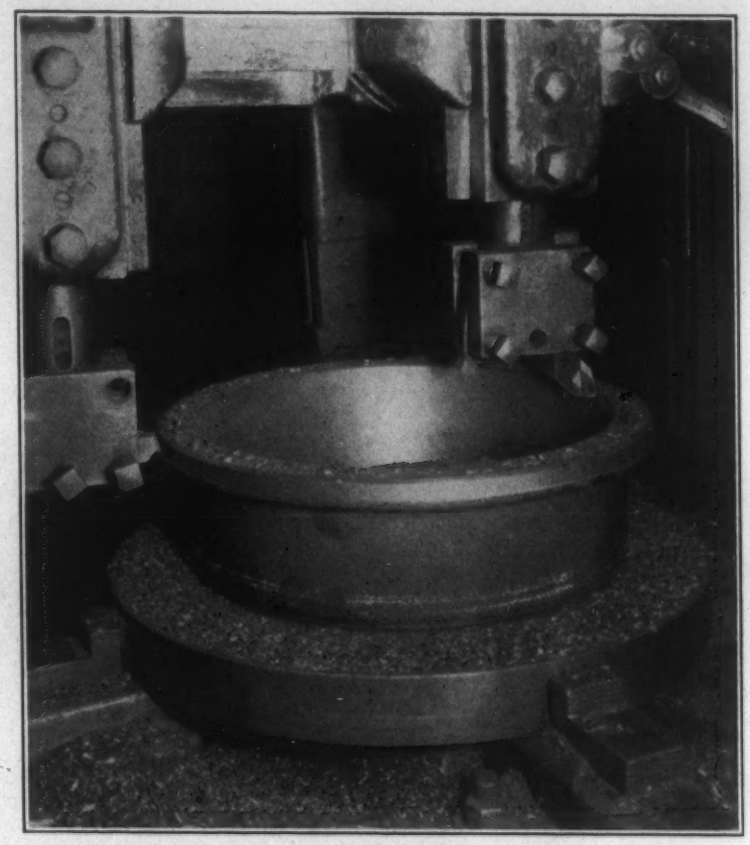

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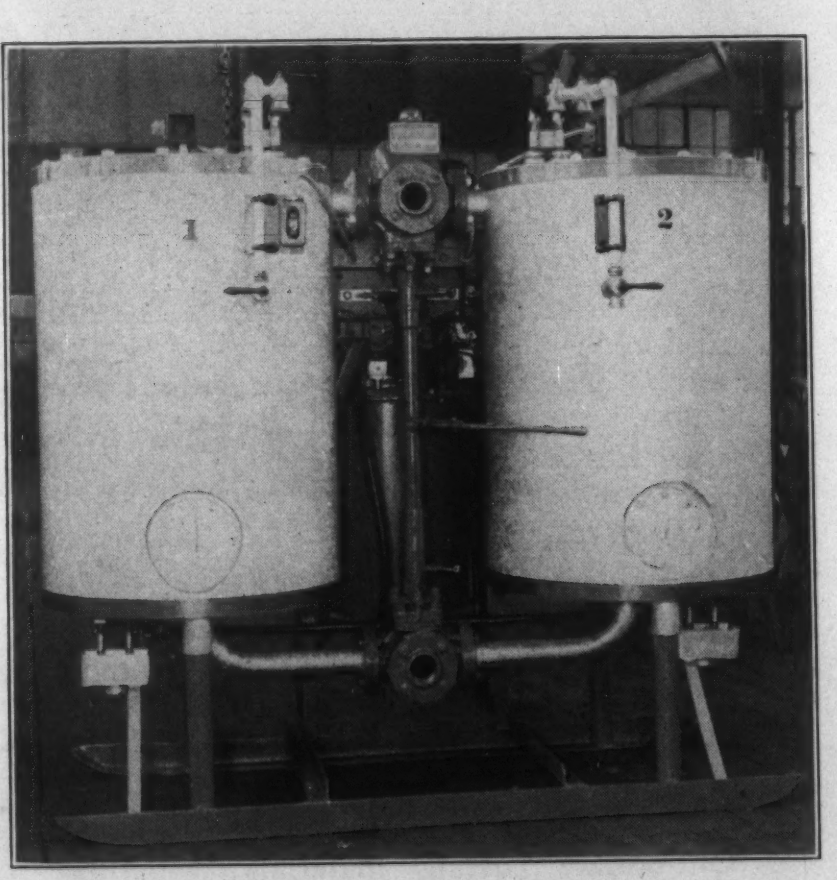

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5. HEAT TREATMENT

O. E. HARDER, SECTION EDITOR

1

Study of Heating Alloy Steels. N. Y. Taitz. *Domez*, No. 1, 1935, pages 41-60. In Russian. Study of phenomena occurring on heating steels under conditions approaching those used in tube piercing. The influence of physical constants, mechanical and plastic properties, structure of metal and of the size and shape of the heated piece are comprehensively presented in the first part of the paper based on published data taken from 53 bibliographic sources. Two steels, 0.32 C,0.63 Mn, 0.028 P,0.045 S, 0.37 Si,1.15 Cr,0.17 Mo and 0.20 C,0.47 Mn, 0.022 P,0.11 Si,18.9 Cr,7.5 Ni were used as samples. Up to 1000°C., dilatation of

2

stainless steel was larger than of Cr-Mo steel and followed almost a straight line (Chevenard dilatometer). Cr-Mo steel shrinks in the interval 750°-800°C. Its dilatation coefficient is 13.8 x 10^{-6} in the range 300-400° C., 16.0 x 10^{-6} between 350° and 400°C. and the coefficient of shrinkage between 750° and 800°C. is 29.2 x 10^{-6}. Cylinders of 3 sizes made of these steels were provided with properly mounted thermocouples and heated in an oil-fired plant furnace. The results of temperature distribution measurements in Cr-Mo steel agreed well with the theoretical values calculated from the formulas found in the literature. Thermal conductivity for it was found as 180 Cal/m²/hour. For stainless steel the values obtained were less than the theoretical which was caused by its polished surface. Its thermal

3

conductivity was 140 Cal/m²/hour. Heat conductivity drops on heating more than any other property. Numerous calculations showed increasing difference in temperature within a heated sample of steel with decreasing heat conductivity. The maximum difference in all cases is observed during the first moments of heating, dropping gradually afterwards. Maximum difference increases with the rise of furnace temperature and decrease of heat conductivity, and depends in direct proportion on the thickness of the heated object. (5)

4

Electric Resistance Furnaces for Industrial Heat Treatment (Les Fours Electriques à Résistance pour Traitements Thermiques Industriels). M. Etienne. *Electricité* (*Science et Industrie*), Vol. 19, Apr. 1935, pages 158-166. General article dealing with the following: (1) Quenching, (2) Annealing, (3) White annealing, (4) Drawing, (5) Case hardening, (6) Nitrogen-hardening. FR (5)

5

Protective Gases Which do Not Carburize or Decarburize (Schutzgas, das weder kohlt noch entkohlt). *Feuerungstechnik*, Vol. 22, Mar. 15, 1934, pages 36-37. Three hours annealing of 0.2 C boiler plate in a mixture of 20% H_2O and 80% N increased the weight by 0.0166 g./cm.², and 0.0024 g./cm.² in a mixture of 20% CO_2 and 80% N. The following gas mixtures proved to be neutral: (1) 58 CO, 42 CO_2, (2) 50 H_2, 50 H_2O, (3) 57 H_2, 43 CO_2, (4) 80 CO, 20 H_2O, (5) 30 CH_4, 35 CO_2, 35 H_2O. These mixtures cannot be obtained by the combustion of illuminating gas and thus are not feasible with reverberatory furnaces. In the case of muffle furnaces, a neutral atmosphere was obtained by passing the gas first over turnings at 980° C. The analysis changes were as follows:

	neutral gas I	after treatment I	neutral gas II	after treatment II
CO_2	2.00	1.55	2.44	0.1
O_2	1.58	—	1.55	—
C_nH_m	2.45	0.51	2.78	—
CO	7.60	10.48	7.15	18.1
CH_4	23.80	20.96	27.95	2.68
H_2	49.75	54.6	47.00	68.6
N_2	12.82	11.9	11.13	10.52

WH (5)

6

7

Heat Treatment of Gray, White and Malleable Cast Irons. H. Bornstein. *Industrial Heating*, Vol. 2, May 1935, pages 235-238; June 1935, 289-292. Heat treatment is applied to gray cast Fe either in the form of annealing for relief of internal stresses within a temperature range of 850°-1000° F., or in the form of quenching and drawing in order to secure greater hardness and strength of a particular cast Fe; the strength drops after hardening but increases with the drawing or tempering temperature. Besides these 2 forms, special heat treatments are applied in the form of nitriding, especially for an iron with about 1% Al content. Such castings are first air-hardened and drawn before nitriding. Malleable Fe is produced through graphitization of white cast Fe. The different processes are discussed, procedures as to proper heating and holding at definite temperatures, compositions fitted for certain processes, and metallographic features and mechanical properties are described. Ha (5)

8

5a. Annealing

Stamping Annealed Scale-free in Continuous Furnace. A. G. Seger. *Steel*, Vol. 96, Mar. 4, 1935, pages 57, 73. See "Clean Annealing at Motor Wheel Corporation," *Metals & Alloys*, Vol. 6, May 1935, pages MA 184R/10. MS (5a)

9

5b. Hardening, Quenching & Drawing

Experience Shows Value of Heat Treatment. C. H. R. Howe. *Railway Engineering & Maintenance*, Vol. 31, May 1935, pages 289-291. The heat treatment of both new and welded rail ends definitely extends rail life. The heat treating process consists of hardening the upper surface of the head for a distance of about 2" back from each end. The Brinell hardness is raised about 100 units, the increased hardening of the metal tapering off gradually into the head to a

10

depth of from ¼"-⅜". Chart records of 28 months' tests made by the Chesapeake & Ohio of heat treating and beveling new rail ends are presented showing the progressive batter with different forms of end treatment and also the extent of chipping. The experiments showed that the life of heat treated rails will be 4 times that of those without heat-treated ends. WH (5b)

Hardening of Tool Steels (Härtung der Werkzeugstähle). H. KALLEN & K. GEBHARD. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Apr. 6, 1935, pages 437-440. The various hardening processes for tool steels, their theoretical principles and applications in practice are reviewed. Cold-hardening is defined as an increase of hardness by hammering, drawing, rolling below recrystallization temperature. Heating above 500°-600° C. removes the effect of cold-working again due to reformation of the structure. Annealing below this temperature changes mechanical and physical properties due to crystal recovery. Quench hardening is the usual process applied to tools; to obtain proper hardness the steel must first be cooled with the critical velocity; the subsequent cooling can be less rapid. Interrupted hot-hardening is a process in which the pearlite transformation is first suppressed by sudden cooling and then martensitic crystallization is facilitated by slow cooling. Precipitation hardening is practiced particularly in light metal alloys; it is characterized by the increase of the solubility ratio of 2 phases with temperature. Recently precipitation-hardening iron alloys are also made, e.g. α-Fe in the system Fe-W can contain about 20% W at 1400° C. while at room temperature only about 8% W are present in the solid solution. If by sudden cooling the establishment of the new equilibrium is prevented an oversaturated solid solution at room temperature is obtained which is a fairly soft and easily machinable alloy. Drawing at 500°-600° C. precipitates W in very fine distribution as Fe_3W_2; such precipitation can increase hardness to glass hardness. The different processes, testing of hardness and cooling agents are described in detail. 11 references.
Ha (5b)

Local Surface Hardening of Crankshafts (Oertliche Oberflächenhärtung von Kurbelwellen). H. VOSS. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, June 15, 1935, pages 743-749. The economical advantages of local hardening by the oxyacetylene flame and the best methods to carry it out are discussed. It is employed for hardening of gears, shafts and especially crankshafts. The hard layer has a thickness of several mm. around a core of hardened material. The steel used in this process should be alloyed in such manner that, after local heating above the transformation point, Ac_3, the heated parts assume a greater hardness; the heat supply to the surface must be considerably faster than the heat conduction to the core. Experiments have shown that the process gives best results if the depth of hardness is 0.05 times the diameter of the shaft. A Cr-Mo steel of 86 kg./mm.² tensile strength showed in the hardened zone 205 kg./mm.², elastic limit 190 kg./mm.², reduction of area 30%, elongation 5%, notch-toughness (Mesnager) 2.5 kg./mm.² This result is ascribed to the very fine form of martensite in the hardened zone. The particular advantage of local hardening is that eventual warping of the piece takes place in the hardened zone only so that the piece as a whole is not so much affected, and eventual deformations can easily be corrected; the thickness of the hardened zone can easily be made greater than with case-hardening or nitriding.
Ha (5b)

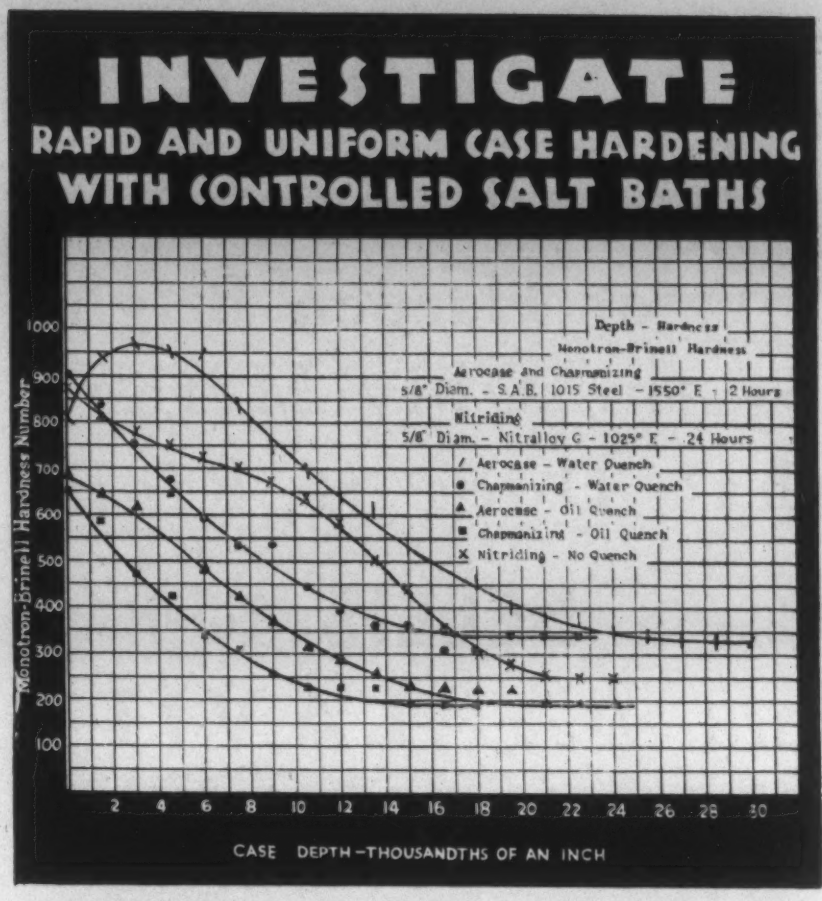
Prolonged **Tempering at 100 Degrees Cent. and Aging at Room Temperature of 0.8 Per Cent Carbon Steel.** G. A. ELLINGER & R. L. SANFORD. *Transactions American Society for Metals*, Vol. 23, June 1935, pages 495-510. Paper read and discussed at A.S.M. Convention, 1934. Previously abstracted from Preprint 8. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 518.
WLC (5b)

5c. Aging

Testing Sheets for Blue-Brittleness and Stability against Changes Due to Aging. E. L. KENYON & R. S. BURNS. *Sheet Metal Industries*, Vol. 8, Aug. 1934, pages 445-448; *Iron Age*, Vol. 134, Aug. 9, 1934, pages 26-28. See *Metals & Alloys*, Vol. 6, May 1935, page MA 186L/5.
AWM + VVK (5c)

On the **Age Hardening of Brass.** KANZI TAMARU. *Bulletin Institute of Physical & Chemical Research*, Tokyo, Vol. 14, Mar. 1935, pages 139-145. In Japanese. *Scientific Papers & Abstracts of the Institute of Physical & Chemical Research*, Tokyo, Vol. 26, Mar. 1935, page 11. In English. On aging 1:6 brass, Hansen in 1930 observed an incubation time and concluded that the electric resistance does not increase for several minutes. Doubting that the electric resistance in the (heterogeneous) equilibrium state is larger than in the as quenched state, the author studied brass containing 59.11% Cu after quenching from 870° C. and aging at different temperatures in vacuum and found: (1) there are no incubation times in electric and hardness measurements; (2) the electric resistance of quenched samples is larger than that of annealed ones; (3) the electric resistance in the quenched state was nearly the same as the sum of 3 electric resistances, i.e. that of the annealed state, that due to quenching stresses and due to the transformation; (4) during aging, a slight heat absorption was found near 130° C. and at 460° C., a small heat evolution at 260° C. and a larger one at 310° C. The first heat absorption is attributed to an atomic rearrangement and the one at higher temperature to the transformation from $\beta' \longrightarrow \beta$. The small heat evolution is due to the separation of the α phase from β and the larger one to the transformation from $\beta \longrightarrow \beta'$.
WH (5c)

Influence of Various Elements on Precipitation Process in Steel on Drawing (Einfluss verschiedener Elemente auf die Ausscheidungsvorgänge im Stahl beim Anlassen). W. TOFAUTE. *Technische Mitteilungen Krupp*, Vol. 2, No. 5, Dec. 1934, pages 134-135. See W. Eilender, A. Fry and A. Gottwald, *Stahl und Eisen*, Vol. 54, 1934, pages 554-564 and 680-681. (*Metals & Alloys*, Vol. 5, page MA 518). This article summarizes the work of these 3 authors, which dealt with (1) the precipitation process in pure Fe as the result of additions of C, N, O and Cu, (2) the effect of the addition of other elements commonly present in steels, and (3) a study of the particle size of the precipitate and its correlation with mechanical properties. The alloys were made in vacuum. The properties measured were electrical conductivity, coercive force, retentivity and hardness, each of which was shown to reach a maximum at a different annealing temperature. In carbon steels Ti and V restrain age hardening by tying up C in a form insoluble in α iron; Zr and Ta probably have a similar effect; Mo, Cr and Mn are needed in greater quantities to have this effect. In nitrogen bearing steels Al, Zr, Ti and V prevent aging as soon as enough is present to form nitrides with all the N present, while Mn, Si, Mo and V are needed in greater amount. In Cu age hardening, C and Mn restrain although C has no effect in the presence of an element which prevents age hardening due to C. No aging was produced by O. Flow figures developed by the Fry technique are restrained or weakened by the same elements which restrain N-aging.
MG (5c)



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5d. Malleableizing

Malleable Castings. Albert Sauveur & Harry L. Anthony. *Transactions American Society for Metals*, Vol. 23, June 1935, pages 409-430. Paper read and discussed at A.S.M. Convention, 1934. Previously abstracted from Preprint 4. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 518. WLC (5d)

5e. Carburizing

An Investigation of Some Methods of Preventing the Formation of the Abnormal Structure in Carburized Steel. I. Hiroshi Sawamura. *Tetsu-to-Hagane*, Vol. 21, Feb. 25, 1935, pages 67-72. Abnormal structure was seen in the armco Fe carburized in a mixture of charcoal powder and $BaCO_3$ at 900° and 1000° C. while it was hardly found in the specimens carburized in the current of CH_4, C_2H_4 and C_2H_2 at 900° C. especially in C_2H_2. If the assumption that the formation of the abnormal structure in carburized steel is mainly caused by O_2 containing steel in comparatively large amounts is true, these phenomena can be explained as these gases deoxide and carburize the iron simultaneously at high temperature. TS (5e)

Origin and Prevention of Hardness and Grinding Cracks and of Spalling of the Hardened Layer of Case-Hardened Materials (Ueber die Entstehung und Verhütung von Härte- und Schleifrissen sowie des Abblätterns der Härte- schicht an einsatzgehärteten Werkstoffen). Richard Koch. *Automobiltechnische Zeitschrift*, Vol. 38, June 10, 1935, pages 276-279. The best method of case-hardening, especially for automobile parts, is cementing as in addition to the glass-hard outer layer a tough core is obtained. The different ways of case-hardening steel of different composition are discussed and their testing described. The reason for cracks forming in the hardened layer is usually that the pieces when quenched in water instead of in oil warp and deform very much so that the hardened layer spalls off; this becomes still more pronounced if the pieces are overcarburized, at too high hardening temperatures, or if the temperature is increased too rapidly. To straighten deformed parts they must be heated to 200° C. but not higher. A steel which does not warp is the alloy steel with 6% Ni, 1% Cr and 1% C; after case-hardening it is cooled slowly in air from 800° C. and becomes glass-hard. When grinding case-hardened pieces heating must be avoided, the pressure must not be too high as the cooling water is squeezed out, and expansion followed by rapid cooling takes place causing fine cracks. Ha (5e)

Effect of Alloying Elements on the Carburization of Steel (Einfluss der Legierungselemente auf das Verhalten von Stählen bei der Einsatzhärtung). E. Houdremont & H. Schrader. *Archiv für das Eisenhüttenwesen*, Vol. 8, Apr. 1935, pages 445-459. The effect of various elements on the C content of the carburized layer, depth of carburization and hardening, structure, and susceptibility to overheating was studied. The addition of carbide forming elements like Cr, Mo, W, V, and Ti raised the C content of the carburized layer, whereas the addition of Si, Al, Ni, Co, Cu, and P, lowered it. Most of the addition elements tended to reduce the depth of carburization, although this effect was small with Ni, Co, and Cu, possibly because they did not lower the rate of diffusion. Since most of the elements increase the hardenability, it followed that the depth of hardening in steels with Mn, Ni, Cu, Cr, Mo, was increased, even though the carburized layer was shallower. Co, on the other hand, lowered the hardenability and hence the depth of hardened layer; V and Ti tended to have a similar effect apparently because of the formation of stable carbides. The addition of the carbide forming elements Cr, Mo, W, and Ti increased the amounts of free carbides in the outer zone; the addition of Si, Al, and Ni tended to cause graphitization. Mo and W tended to cause an abnormal structure; Ni and Cu less so. Mo, W, V, and Ti had a strong effect in causing fine grain after carburization; Mn, Ni, Co, Cu, and Si had a lesser effect; Cr and Al in the amounts added (1.5 to 3%) increased the sensitivity to overheating, i.e., they made the steels coarser grained. SE (5e)

Physical Properties of Case Hardened Steels. O. W. McMullan. *Transactions American Society for Metals*, Vol. 23, June 1935, pages 319-381. Paper read and discussed at A.S.M. Convention, 1934. Previously abstracted from Preprint 7, 1934. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 519. WLC (5e)

Decarburization, Its Prevention and the Recarburization of Ferrous Objects (Die Entkohlung, ihre Vermeidung und die Wiederaufkohlung stählerner Werkstücke). H. Reininger. *Metallwaren Industrie & Galvano-Technik*, Vol. 33, Dec. 31, 1934, pages 16-19; Jan. 15, 1935, pages 36-37. The structure of soft and hard steels is shown in 13 micro-photos and the underlying heat treatments are discussed. Steel surfaces often fail to respond to hardening due to decarburization. This phenomenon, which is based on a number of oxidation reactions is discussed mainly on the basis of investigations by R. Schenk & collaborators. It is stressed that gas mixtures are unsuited for prevention of decarburization. They either react with the work or, in case of initial passivity in chemical and physical regard, exert an unfavorable influence by upsetting equilibrium conditions. Annealing in salt baths free from O is more suitable in principle. Decarburized surface layers can be enriched in C by KCN or NaCN baths. The "Durferrit" cyanide baths are widely used. At 850° the depth of penetration varies as follows with respect to hardening times: 30 min. = 0.35 mm.; 120 min. = 0.50 mm.; 240 min. = 0.60 mm. Diagrams are presented which show the C and N content at 0-0.7 mm. depth in relation to bath temperature (850° and 950° C.) and time (2 and 4 hrs.). EF (5e)

Steels Manufactured in France: Steels for Special Uses (Les Aciers de Fabrication Francaise: Aciers d'Usages Particuliers). *Métaux et Machines* (*Science et Industrie*), Vol. 19, May 1935, pages 166-170. Discusses case-hardening steels, composition and treatment. FR (5e)

5f. Nitriding

Investigations into the Nitrogen-Hardening of Steels. Part IV.—The Nitriding of High-chromium and Austenitic Steels at Various Temperatures. B. Jones. *Carnegie Scholarship Memoirs, Iron & Steel Institute*, Vol. 23, 1934, pages 179-204. In austenitic Mn steels (13-18% Mn) the maximum hardness occurs after nitriding at 550°. These steels are not hardened effectively by nitriding at 600° C. due to the growth of a wide marginal layer of nitride, associated with iron/iron-nitride eutectoid. This unsatisfactory structure does not appear after a 2-stage nitriding, first at 500° C. and then at 600° C. Nitriding at elevated temperatures does not cause hardening of a Ni austenitic steel, but a Ni-Mn steel may be nitrided by treatment at 600° C. High-Cr and austenitic-Ni steels should be nitrided at temperatures higher than 500° C. Deleterious structures in marginal layers of low-Cr and certain austenitic Mn steels after high temperature nitriding did not occur in high-Cr and austenitic Cr steels. The greatest surface hardening and depth-hardening of an 18/8 Cr-Ni steel (with and without 1% Al) occurred at 550°. It was necessary to increase the nitriding temperature to above 550° C. to harden effectively the Cr-Ni-W heat-resisting steels. A more even surface hardness was obtained in a 14/14/2 Cr-Ni-W steel than in a steel with higher Ni. Austenitic steels containing 23-25% Cr and 10-13% Ni were found to harden to the maximum value at 635°-645° C. 7 references. CW (5f)

Investigations into the Nitrogen-Hardening of Steels. Part III.—The Nitriding of Steels Containing a Low Alloy Content of Chromium and Aluminum at Various Temperatures (including results obtained by two-stage nitriding). B. Jones. *Carnegie Scholarship Memoirs, Iron & Steel Institute*, Vol. 23, 1934, pages 139-178. Effective surface-hardening can be induced in most types of nitriding steels with low Cr and Al contents on nitriding at 460° C. for 48 hours using a controlled ammonia dissociation. Commercial Cr-V and Cr-Al-Mo nitriding steels show a maximum hardness when nitrided at 460° C. and at 500° C. The maximum hardness developed in the Cr-V steel was 895 and in the Cr-Al-Mo steels 1200 Vickers-Brinell. In a low Cr steel the hardness is decreased when the nitriding temperature is increased to 550° C. An Al-bearing Fe attained its maximum hardness at this temperature. The stabilizing effect of 1% Al in Nitralloy steel has a decided beneficial influence on the nitriding at elevated temperatures. Two-stage nitriding at 500° C. and 600° C. is beneficial to steels containing 1% Al, and gives an appreciable depth of case without a loss of surface hardness. The depth of case obtained in Nitralloy after nitriding for 16 hours using the 2-stage method (500° and 600° C.) was equal to that produced after 48 hours using the usual process (500° C. only). If Al is absent, 2-stage nitriding is not beneficial in low-Cr steels. The maximum temperature that can be used in the 2-stage method is about 600° C. 32 references. CW (5f)

6. FURNACES, REFRACTORIES AND FUELS

M. H. MAWHINNEY, SECTION EDITOR

Advances in Electric Furnace Design. RENE LEONHARDT. *Chemical Engineering & Mining Review*, Vol. 27, Apr. 8, 1935, pages 254-255. A German high-frequency induction furnace of 8-ton capacity is described and illustrated. The furnace consists in the main of the coil, the crucible, and the frame. The usual coils employed are the water-cooled tubular type. The crucible is tamped or fritted with the aid of a pattern, with the latter method giving the greater durability. By the use of a non-magnetic material for the frame structure, the dimensions of the frame structure can be minimized. This construction is satisfactory for furnaces of 1-1.50 ton. capacities. For capacities of 4-8 tons the body is designed as a closed vessel, keeping the magnetic fields away from the interior vessel structure by screening. WHB (6)

Losses of Metallurgical Coke in Coke and Blast Furnace Plants. YA. O. GABINSKY, A. C. BRUCK & A. E. GEISSLER. *Domez*, No. 1, 1935, pages 9-17. In Russian. 84.3-89.3% of coke leaving the coking ovens reaches the blast furnaces. The rest, in sizes less than 25 mm.², is lost during different handling processes. The influence of these processes is treated in detail. With any given equipment greater losses occur when the coke has lower mechanical properties. (6)

High Temperature Insulation for Industrial Furnaces. N. ALLEN HUMPHREY. *Blast Furnace & Steel Plant*, Vol. 22, Dec. 1934, pages 703-704, 712; Vol. 23, Jan. 1935, pages 85-87; Feb. 1935, pages 134-135; Mar. 1935, pages 198-199, 212-214; Apr. 1935, pages 267-268. See *Metals & Alloys*, Vol. 6, May 1935, page MA 189L/2. MS (6)

Melting Metals Electrically. GEORGE H. HILL. *Electrical World*, Vol. 105, May 11, 1935, pages 25-27. Basic types of electric melting furnaces are: (a) direct-arc furnaces; (b) indirect-arc furnaces; (c) induction furnaces; (d) resistor furnaces. Characteristics and appropriate applications of each type are cited. CBJ (6)

Gas Permeability, Compressive Strength, Heat Conductivity, Thermal Expansion, Heat Capacity and Tendency Towards Cracking of Refractory Bricks in Relation to Porosity (Gasdurchlässigkeit, Druckfestigkeit, Wärmeleitfähigkeit Wärmeausdehnung, Wärmekapazität und Neigung zum Springen von feuerfesten Steinen in Abhängigkeit von der Porosität). HEINRICH HERBST. *Feuerungstechnik*, Vol. 22, Oct. 15, 1934, pages 115-116. Experimental results are clearly presented in a table and diagram which must be consulted for detailed information. A desirable degree of porosity can be secured by mixing cork dust, flour or gas liberating agents to the refractory material before firing. WH (6)

Regulating the Heat Generation and Distribution in Heating Furnaces Through Air Inlets (Die Regelung der Wärmeentwicklung und Wärmeverteilung in Glüh-und Wärmöfen durch unterteilte Luftzufuhr). E. SENFTER. *Archiv für das Eisenhüttenwesen*, Vol. 8, Apr. 1935, pages 427-431. The design of the furnaces and the location of the burners and air inlets for attaining better temperature uniformity are described. SE (6)

Refractory Bricks Containing Zirconium for Furnace Construction (Zur Verwendung von zirkonhaltigen feuerfesten Steinen im Ofenbau). *Die Metallbörse*, Vol. 24, Nov. 28, 1934, page 1514. Natural occurrences of Zr ores, manufacture, chemical analyses and physical properties of ZrO-containing refractories are reviewed. Tested under identical testing conditions, they compare as follows with other standard refractories:

	zirconium-	carborundum-	chamotte-	silica-bricks
brittleness	24	30	13.7	12
compressive strength	590	500	300	200
tensile strength	104	100	50	20
porosity	12.7	19	14	16
linear expansion x 10^{-7}	8.4	48	variable	54
softening point °C.	2200	1600	1300	1400
melting point °C.	2600	1700	1500	1700
density	4.4	2.4	2.5	2.2
hardness	7.5	8	4	5

Low thermal expansion coefficient, low thermal conductivity, chemical resistance against basic and acid slags and the high melting point, which can be raised to 3000° C. by increasing the ZrO content are the principal advantages; and brittleness and high price the drawbacks. EF (6)

Trends of Research in Refractories Used in Steel Plants. J. H. CHESTERS. *Brick & Clay Record*, Vol. 86, Mar. 1935, pages 96-97. Recent work on fireclay, silica, magnesite bricks and special refractories of beryllia, zirconia tungsten carbide and metallic oxides to obtain a refractory for the highest temperatures at present available in furnace work (up to 1750° C.) is reviewed briefly. Ha (6)

Refractory Products (Les Produits réfractaires). V. BODIN. *Usine*, Vol. 44, Apr. 18, 1935, page 27. Refractory products are defined as those substances with melting points exceeding 1500° C.; two groups are distinguished: one having a base of Si and Al, and the other containing all other materials. Composition and properties of these materials are discussed briefly. Ha (6)

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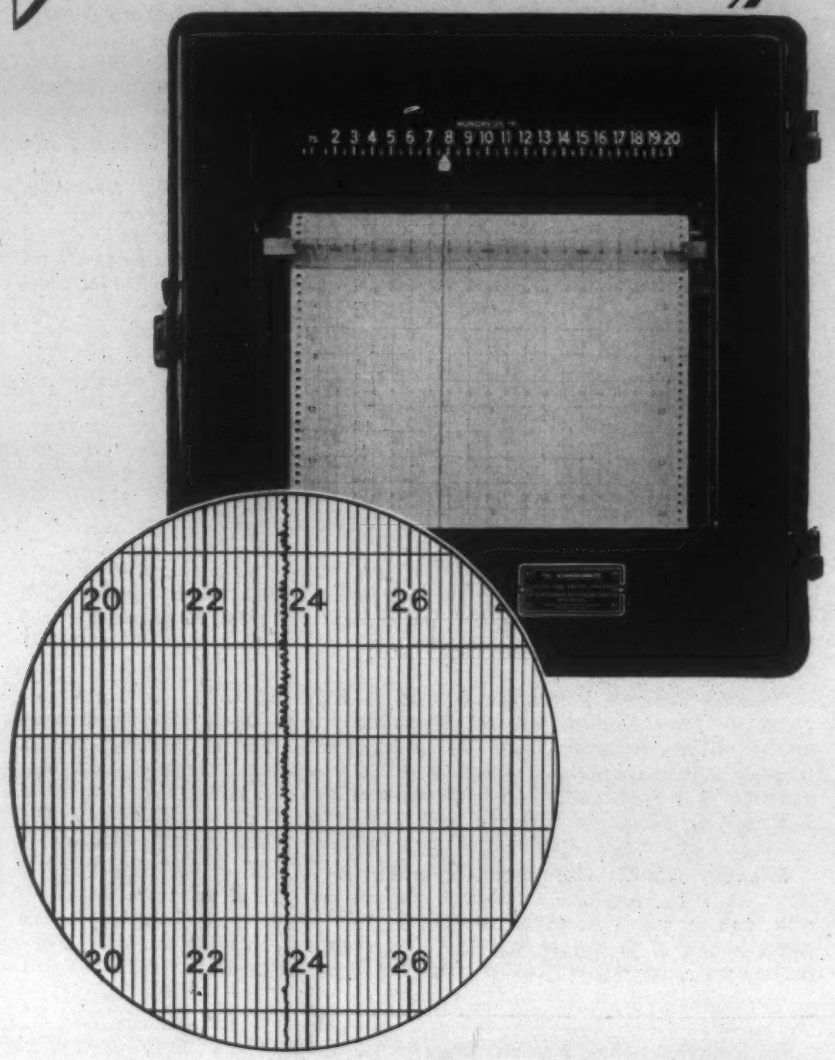

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The Selection and Operation of Gas and Oil-fired Heat-treating Furnaces. G. H. Barker. *Metallurgia*, Vol. 11, Apr. 1935, pages 145-146. Discusses factors to be considered in selecting furnaces for particular services and stresses advantage of automatic control. JLG (6)

1 **Low Frequency Induction Furnaces.** G. H. Clamer. *Metal Progress*, Vol. 27, May 1935, pages 54-55. 60 cycle induction furnaces have not been exploited by Ajax Electrothermic Corp. although they own the controlling patents in U. S. and Canada, because of very poor power factor and efficiency and need for molten melt charge. WLC (6)

— **Protection from Oxidation of Electric Furnace Electrodes.** G. F. Morenko. *Domez*, No. 1, 1935, pages 61-62. In Russian. Smearing the surface of electrodes with a slurry of ground fire brick with sodium silicate protects electrodes well, but the protecting coating is rubbed away by electrode holders. Metal coating by spraying produces a mechanically strong coating with some protective power. A layer 0.2 mm thick of steel or iron appears to be the best, though all coatings peel off on heating.
2 (6)

— **Effect of Excess Air on Fuel Rate.** L. T. Pearsall. *Heat Treating & Forging*, Vol. 21, May 1935, pages 247-249. Using continuous steel heating furnace for illustration, shows that heat losses due to excess air used in combustion of fuel may be considerably higher than generally supposed. MS (6)

Use of Electric Furnaces in Industrial Heat-treatment. Part III. A. Glynne Lobley. *Metallurgia*, Vol. 12, May 1935, pages 9-13. Describes furnaces
3 used for bright annealing and for non-scaling heating for hardening. JLG (6)

— **Chromite.** Gordon H. Chambers. *Foote Prints*, Vol. 8, June 1935, pages 1-8. Discussion of occurrence, preparation and uses for chromite for refractory, metallurgical, chemical and ceramic industries. Silica is most objectionable impurity for refractories and Fe ranks second as objectionable due to reduction of fusion point when they are present. A special grade of air-floated chromite is principal coloring agent in the production of emerald and Dutch green glass. Pink glazes on ceramics are obtained by a mixture of chromite and Sn oxides. Other ceramic colors are obtained with other combinations with Cr oxide and other metal
4 oxides. The production of Na bichromate is reviewed and the various uses for bichromates in chemical manufacturing, corrosion inhibiting, etc., are discussed. WB (6)

— **Forsterite and Other Magnesium Silicates as Refractories.** R. E. Birch & F. A. Harvey. *Journal American Ceramic Society*, Vol. 18, June 1935, pages 176-192. Investigations were carried out with talc serpentine and olivine alone and with added MgO to determine suitability as refractory. The physical properties of the forsterite refractory are discussed and tabulated in comparison with other types of refractory. Microscopic and mineralogical data on the for-
5 sterite are reported. The basicity of the new material was determined. Some notes are included on a method derived for rational analysis of olivine-bearing rock which permits the estimation of the percent of principal minerals in the samples. WB (6)

— **Balanced Blast Cupola.** J. G. Pearce. *Metal Progress*, Vol. 27, June 1935, pages 59-60. Describes use of auxiliary tuyeres with finely adjustable valves for control of air supply, resulting in complete combustion of coke and low CO (1.5%) in the top gases. WLC (6)

6 **Novaculite as a Refractory Material.** C. W. Parmelee. *Brick & Clay Record*, Vol. 86, June 1935, pages 205-210. Novaculite is a hard, white, compact rock of almost pure silica, known as "chert"; its mechanical and physical properties are fully described. Ha (6)

— **Destruction of Refractory Bricks in Melting Furnaces Due to Cracking (Zur Zerstörung von feuerfesten Schmelzofensteinen durch Zersplitterung).** E. R. Richards. *Feuerungstechnik*, Vol. 23, May 15, 1935, pages 49-52. Critical discussion of effect of temperature changes. It is pointed out that bricks from the same shipment show different service times. Density and physical property changes
7 are due to the weight of bricks placed on top of each other during firing. In the melting furnace as little mortar as possible should be used. Tendency towards cracking is also reduced by starting a furnace as slowly as possible. Mechanical injuries hardly occur above 800°C. Undue stresses due to heat expansion result in spalling. An adjustment of the anchorage or card-board in every third or fourth joint is a counter-measure. Structural changes of refrac-
— tories due to thermal or chemical effects are also a contributing factor to cracking besides abrupt temperature changes and continuous heat cycles. Preparation of hearths is discussed. WH (6)

8 **Forging Furnaces.** A. M. Steever. *Industrial Heating*, Vol. 2, Mar. 1935, pages 127-129; Apr. 1935, pages 177-180; June 1935, pages 301-302. Furnaces for forging and heat treating of ferrous and non-ferrous metals, temperatures to be applied to avoid scaling or slagging, their operation and principal design features are discussed at length. Ha (6)

— **A Graphical Method of Calculating Heat Loss Through Furnace Walls.** Clarence E. Weinland. *Transactions American Society for Metals*, Vol. 23, June 1935, pages 431-454. Paper read and discussed at A.S.M. Convention, 1934. 8 references. Describes a graphical method for solution of problems in steady state
9 heat loss through furnace walls. Due to temperature effects upon thermal conductivity its use in calculations over a wide temperature range is difficult. The use of a new function, "true" conductivity, obviates this difficulty and makes possible the graphical calculation of heat transmission through compound structures. A typical problem is worked out. WLC (6)

— **New Refractory for Open Hearth and Electric Steel Furnaces (Ein neuer feuerfester Baustoff für Siemens- Martin- und Elektrostahlöfen.)** E. Reitler. *Feuerungstechnik*, Vol. 22, Mar. 195, 1934, pages 29-30. See *Metals & Alloys*, Vol. 5, June 1934, page MA 260. WH (6)

10 **Pulverized Fuel in the Metallurgical Industry.** J. H. Mahler. *Proceedings South Wales Institute of Engineers*, Vol. 51, May 10, 1935, pages 79-104. See *Metals & Alloys*, Vol. 6, June 1935, page MA 288R/1. AHE (6)

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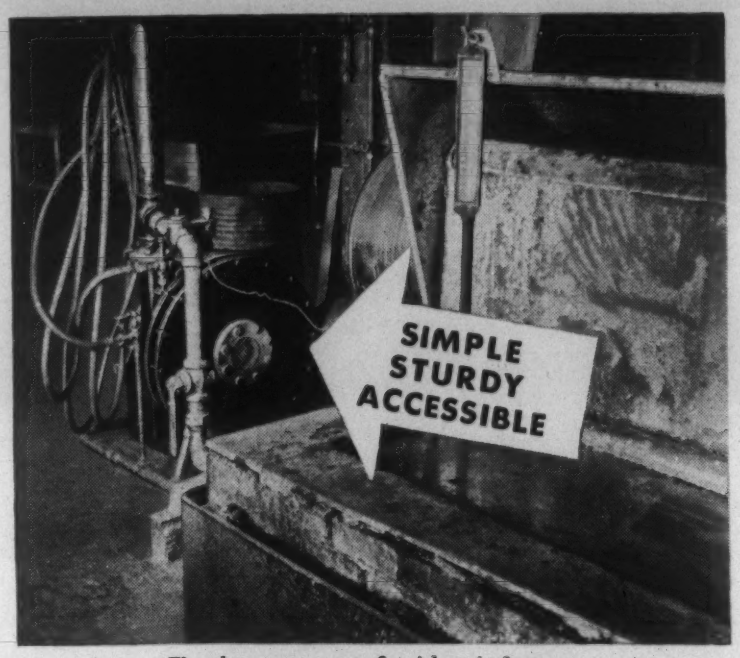

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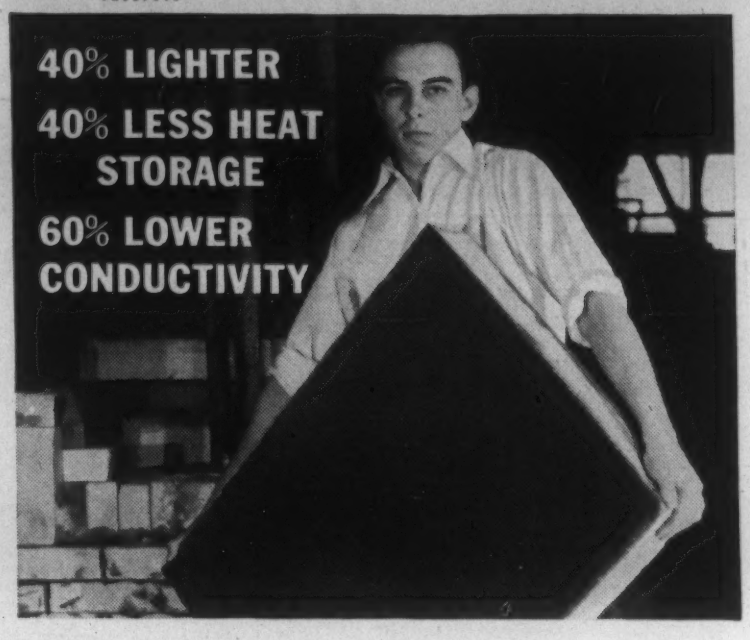

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7. JOINING

7a. Soldering & Brazing

Electric-Furnace Brazing Process Finds New Uses. H. M. WEBBER. *Iron Age*, Vol. 135, Apr. 25, 1935, pages 12-15. Points out new applications of electric furnace brazing in sewing and business machines and refrigerator manufacture, and progress made during the last 2 yrs. Sewing machine parts subject to extreme vibration often worked loose in service when assembled by ordinary method. Electric furnace brazing has eliminated this. In addition to increasing strength of parts the new process reduces production and service costs. Business machine manufacturers are producing levers with hubs, cam clusters, gear clusters, etc. by this method. In plant of General Electric Co. a mesh-belt conveyor type furnace is used in manufacture of refrigerator parts. VSP (7a)

The Penetration of Steel by Soft Solder and Other Molten Metals at Temperatures up to 400° C. L. J. G VAN EWIJK. *Journal Institute of Metals*, Vol. 56, Feb. 1935, pages 109-118 (Advance Copy No. 695). Investigation of the failure of a Ni-Cr steel axle tube of an aeroplane showed that the steel had been weakened by intercrystalline cracks due to the soft-soldering operation. Experiments were made with test pieces of a number of steels by stressing the steel during exposure to a molten metal at temperatures up to 400° C. Cracking occurred in several Ni-Cr steels but not in C steels. Tempering temperature had little influence on tendency to crack. When cracking occurred microscopic examination showed characteristic intercrystalline penetration by the molten metal. 7 references. JLG (7a)

7b. Welding & Cutting

E. V. DAVID, SECTION EDITOR

Stress Relief of Fusion-Welded Pressure Vessels. D. S. JACOBUS. *Journal American Welding Society*, Vol. 14, May 1935, pages 6-7. The need for stress relief of unfired pressure vessels is shown by the failures obtained in welded structures subjected to intermittent or pulsating stress tests. The residual stresses in the welded structure have little or no effect on the bursting strength in the usual hydrostatic test. Precautions necessary in local stress relief and in two-heat stress relief of large structures are indicated. WB (7b)

Street Cars of Arc Welded Steel Construction (Strassenbahnwagen in lichtbogengeschweisster Stahlkonstruktion). *Montanistische Rundschau* (Section *Stahlbau-Technik*), Vol. 27, May 16, 1935, pages 5-6. Discusses the construction of a 47 passenger car of arc-welded Cor-Ten steel, made in the shop of the Pullman Co., Chicago, Ill. Total weight of the car 14,600 kg., a saving of 4,000-9,000 kg. over the type of car commonly used. BHS (7b)

Repair of Heavy Damage to Boilers by Gas Fusion Welding (Behebung schwerer Kesselschäden durch die Gasschmelzschweissung). K. KOHRS. *Autogene Metallbearbeitung*, Vol. 28, Apr. 15, 1935, pages 113-119; May 1, 1935, pages 132-135. Welding, both gas and electric, has proved to be a very good means for eliminating damage due to natural wear and also to other causes if certain precautions are observed. Particularly, faulty spots must never be covered by welds but properly treated mechanically in the welding process. Electric welding in places which are in contact with water should not be done with bare electrodes but with high-grade covered electrodes. A great number of examples are illustrated, cause and nature of defects are described and welding processs for repair described. Ha (7b)

The Requirements for a Good Weld in Steam Boilers and Pressure Vessels (Welche Anforderungen sind an die Schweissung von Dampfkesseln und Dampf- und Druckfässern zu stellen?). KRÜGER. *Autogene Metallbearbeitung*, Vol. 28, May 15, 1935, pages 145-151. Mechanical conditions, chemical composition and construction of a weld to be fulfilled in order to avoid stresses and freedom from pores and to give sufficient strength are discussed in general and correct location and kind of welds for bottoms of vessels are illustrated. Ha (7b)

Outstanding Technical Achievements by Electric Welding (Technische Spitzenleistungen durch Elektroschweissung). A. LION. *Elektrowärme*, Vol. 5, May 1935 pages 104-107. Describes constructions of the dome for an astronomical observatory and pressure conduits for a hydroelectric power station in America. Ha (7b)

Corrosion Resistance of Welds (Résistance des Soudures à la Corrosion). A. LEROY & M. BONNOT. *Revue de la Soudure Autogène*, Vol. 27, Mar. 1935, pages 2-6. Paper read at the 11th Congress of Acetylene and Fusion Welding, Rome. FR (7b)

Repair by Electric Welding of Gear Cases of Diesel Engines in a Submarine (Réparation par Soudure électrique des Carters d'Huile de Moteurs Diesel sur un Sous-Marin). M. LEBRUN. *Revue Générale de l'Electricité*, Vol. 37, Mar. 16, 1935, pages 355-357. Detailed description of repairs of damages due to an explosion. Ha (7b)

Molybdenum in Gray Cast Iron. C. M. LOEB, JR. *Foundry*, Vol. 63, Jan. 1935, pages 24-25, 59. From a paper presented at the June meeting of the Connecticut Foundrymen's Association. Points out that addition of Mo to cast Fe increases transverse and tensile strengths and at the same time increases the deflection. Improved Fe is also produced when alloyed with Ni or Cr, or both. Growth resistance and high temperature strength in Fe are greatly affected by Mo. Mo is added in the spout or ladle in the form of ferromolybdenum, the alloy going into solution in the Fe almost instantly. Castings that crack in the mold are improved by addition of about 0.25% Mo. Includes a table showing the effect of Mo on 3 types of cast Fe. VSP (7b)

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Welding of Aluminum (Zur Frage der Aluminiumschweissung). St. Haarich. *Zeitschrift Verein deutscher Ingenieure,* Vol. 79, Apr. 20, 1935, pages 495-499. Comparative tests are described in which changes in the welded material were studied by using all available welding processes. Electric welding which is not often used was found to give as good results as other processes. The gas content in the seam increases in all processes, in the gas-fusion method it is greatest directly beside the seam. A recrystallized zone occurs next to the seam the width of which is small in the arc-welding and wider in the arc-atom and gas-fusion method. Electric welding produces a finer structure in the seam than arc-atom or gas-oxygen welding. Hardness, tensile strength and stress at the yield point decrease with increasing flame action, elongation shows the reverse. Corrosion resistance of the seam is lower in H_2SO_4 than in acetic acid. The recrystallized zone beside the seam is more resistant than the original material. Velocity of corrosion is increased by hammering. The test results are shown in curves. Ha (7b)

Resistance Welding Methods in the Sheet Metal Industry. L. B. Hunt & C. F. Davidson. *Sheet Metal Industries,* Vol. 9, Jan. 1935, pages 47-50; Feb. 1935, pages 111-114. A general discussion covering the principles and metallography of resistance welding, spot welding and control devices. Electrode tips, unilateral spot welding, automatic repetitive spot and stitch welders, and portable spot welders are discussed in the second installment. AWM (7b)

Current Practices for Welding Aluminum. *Oxy-Acetylene Tips,* Vol. 14, May 1935, pages 101-108. An exhaustive review of essential welding features of Al and its alloys; preparation of work, shaping of ends, welding rods, blowpipes, fluxes, particulars of sheet welding, welding of cast Al and plate Al and alloys, and finishing of welds are discussed in detail. Ha (7b)

Welding as Applied to Vehicular Structures. Stanley E. Evans. *Welding Journal,* Vol. 32, Apr. 1935, pages 106-108, 123. Weight reduction due to welding of freight cars is discussed. Reviews welding of stainless steels of 18/8 with 1% W and 1% Ti which are considered to be stable, weldable and free from any tendency toward weld decay. Such steels are being used extensively in the chemical industry. Discussion also of welding of Cu and alloys and the special technique for Al and its alloys. For Al gas welding is preferred to electric due to the speed of welding being continuously increased during the operation because heat is stored in the work. WB (7b)

Pipe Welding—Practical Field Testing and Instruction of Welders. D. O. Ferguson. *Heating Piping & Air Conditioning,* Vol. 7, June 1935, pages 272-275. Discussion of types of welds made and tested, preparation of coupons by a portable coupon cutting machine. 7 coupons are cut at right angles to the weld, 1 is tested for nick and break, 4 for tensile strength, 1 for ductility and 1 is given a reverse bend test. The various tests are described as made in portable tensile testing machine and the requirements for satisfactory welds outlined. WB (7b)

6 **Use of Welding in Aircraft Construction (Die Anwendung der Schweisstechnik im Flugzeugbau).** W. Kliewer. *Metallwirtschaft,* Vol. 14, May 17, 1935, pages 392-393. Steel is now used to a large extent in the construction of all types of aircraft and welding is playing an increasingly important role in its fabrication. Modern welding methods and materials for Cr-Mo, Mn, and Cr-Mn-Si steels produce welds with excellent strength, ductility, and endurance properties. This enables the use of welded construction for the most highly stressed and important parts. CEM (7b)

7 **Welding Joints in Copper Pipes for Water and Sanitary Installations.** W. L. Kilburn & E. B. Partington. *Welding Journal,* Vol. 32, Apr. 1935, page 102. Bronze welding of Cu pipe with Alda Bronze No. 1 with no flux coating on the rod is discussed. Flux coating on rod provides a surplus which runs down the pipe and is difficult to remove subsequently. WB (7b)

8 **Experiments on the Stress Distribution in Welded Mild Steel Plates (Versuche über die Spannungsverteilung in geschweissten Flusstahlblechen).** O. Mies. *Die Wärme,* Vol. 58, Feb. 16, 1935, pages 97-101. Stress distribution in mild steel plates welded together without clamping was previously investigated (See: Die Wärme, Vol. 57, 1934, page 113). The present paper refers to annealed 0.5″ plates elastically clamped at both ends during welding and cooling down. The gas welded plate could not be evaluated directly since the welding stresses induced were released due to buckling, but the buckling forces have been calculated. Concerning the electrically welded plate, magnitude and direction of the principal stresses, the reduced stresses as well as the normal stresses along the cross and longitudinal section are determined and graphically presented. EF (7b)

9 **Contribution to the One-Dimensional Theory of Welded Joints (Zur eindimensionalen Theorie der Schweissverbindungen).** Heinz Neuber. *Zeitschrift für angewandte Mathematik & Mechanik,* Vol. 15, Feb. 1935, pages 179-180. The one-dimensional theory of Fillunger (*Oesterreichische Wochenschrift für den öffentlichen Baudienst,* 1919, No. 7/8) involves a constant correlating the weld shear stress to the relative shift of the welded edges. Practical utilization of the theory calls for a correct knowledge of this factor which, according to practical observations, varies considerably. Since tables are lacking for consultation, the author studies the problem mathematically. It is deduced that the modulus of shear, G_s, of welds is a characteristic value of the method of welding but it is independent of weld size and shapes. (V weld.) Discussing

10 butt welds, it is urged to determine the ratio $\frac{G_s}{E}$ rather than G_s for the different welding methods. Based on the author's research work, ¼ is a highly probable value for the ratio $G_s : E$. Thus G_s would be around 500,000 which is a reasonable value in view of the oxide inclusions in welds. WH (7b)

Proceedings of the 11th International Congress on Acetylene, Gas-Welding, and Related Industries (Compte rendu du XI-e congrès international de l'acétylène, de la soudure autogène et des industries qui s'y rattachent). J. BRILLIÉ & L. BLOCH-SÉE. *Revue de Métallurgie*, Vol. 32, Mar. 1935, pages 106-119. Summary of papers presented in Rome on June 5 to 10, 1934, which are given here. **Industrial Use of Blow Torches as Seam Removers (L'emploi industriel du chalumeau décriqueleur).** L. DE JESSEY. Blow torches for this purpose were introduced in France from the U. S. They produce a wide jet with a low pressure. Cost of chipping with a chisel grows with the strength of metal but remains lower and constant with the use of these torches. They are much used in France. **Welding Austenitic Manganese Steels (Contribution a l'étude de la soudure des aciers austénitiques au manganèse).** A. PORTÉVIN & D. SÉFÉRIAN. Welding a 14% Mn steel with Mn steel rods produces a weld structurally non-uniform. Gas welding with 18-8 rod gives better results, still better are obtained with electric welding with 18-8 electrodes. Pure Ni wire gives the best uniformity on electric welding. Common steel rods form too much martensite. Higher Ni content of the rods is recommended. **Hardening of the Surfaces by Facing (Le durcissement des surfaces par rechargement).** M. MICHAUD. General information. **Oxyacetylene Cutting Nickel and Chromium Steels (Oxy-coupage des aciers spéciaux au nickel et au chrome).** L. DE JESSEY. Series of investigations to determine the effect of preheating and the speed of feed in cutting showed that with the exception of stainless, Cr steels containing more than 6% Cr all commercial steels can be cut successfully by modifying the cutting conditions. **Blow Torch as a Precision Tool for Superficial Hardening According to Shorter Method (Le chalumeau comme outil de précision pour la trempe superficielle par la méthode Shorter).** A. E. SHORTER. By means of mechanically guided blow torch very efficient quenching of the surfaces can be effected, particularly on gear teeth. **Mechanical Characteristics of some Sheet Samples Brazed with Special Brasses by Means of an Oxyacetylene Torch (Characteristiques mécaniques des soudo-brasures de quelques éprouvettes de toles exécutées avec des laitons spéciaux au chalumeau oxy-acétylénique).** ORLANDO STEGAGNO. Results of physical testing of specimens made of sheets brazed with brasses having 895° and 900° C. m.p. and using borax and boric acid as flux. **Metallographic and Mechanical Properties of Electric Arc Welds (Caractéristiques métallographiques et mécaniques des soudures à l'arc électrique).** I. MUSATTI & A. REGGIORI. In welds made on 0.23 C and 0.28 Si steel with coated electrodes containing 0.08 C and 0.01 Si the zone of maximum hardness corresponds to the transition zone between the metal and the weld. **Resistance to Corrosion in Nitric Acid of Welds Made on Stainless Steels by Means of Oxyacetylene Method (Résistance à la corrosion par l'acide nitrique des soudures autogènes sur aciers inoxydables).** G. FAUSER. A systematic series of researches concerning the influence of the character of the flame on the physical and corrosion resisting properties of 18 Cr 8 Ni stainless steel. **Possibility of Regulating the Deposited Metal by Means of Outside Coatings in Oxyacetylene Welding (Sur la possibilité de varier la composition des métaux d'apport au moyen des enrobages externes dans la soudure oxy-acétyléniques).** E. CREPAZ & S. LOPS. Starting with the experiments of Schun-Ichi Satoh the authors found that it is possible to introduce in the pool of molten metal 2.25-2.55% Ni or 0.3-0.4% Cr according to the thickness of the coating. The same metals can be introduced simultaneously as well as W. Experiments are still in the laboratory stage. **Lack of Weldability of Nickel (Causes d'insoudabilité du nickel).** A. BOUTTE. Office Central de l'Acétylène et de la Soudure Autogène showed in 1929 by a series of comparative tests that Ni does not weld properly when it contains more than 0.02% S and that a certain ratio should exist between Mg present in the metal and S contained in it. **Elimination of Hard Spots and Blow Holes in Welding Cast Iron Pieces (Supression des grains durs et des soufflures dans la soudure des pièces de fonte).** A. BAILLON. Investigation leading to the elimination of these defects are reported and the nature of hard spots is studied metallographically. **Retention of Phosphorus Contained in Impure Acetylene by Steel Welds (Contribution à l'étude de la fixation du phosphore de l'acétylène impur dans la soudure des aciers).** D. SÉFÉRIAN. When the phosphine content of the gas is less than 0.05% no P is retained by the metal. When more than .10% of it is present the P content of the base metal might increase up to 3 times the original, but solubility limit is fixed at about 0.075% P max. **Development of High Quality High Speed Welding in the United States (Developpment des soudures de haute qualité et à grand vitesse aux Etats-Unis).** A. B. KINZEL. Historical sketch of the development. **Refacing of Track. A Study of the Deposited Metal (Rechargement des voies ferrées. Etude du metal déposé).** M. BRUNETEAU. The best results in resurfacing rails are obtained with Cr-Mn steel producing deposits having 65 kg./mm.² tensile strength, 5% elongation and 230-250 Brinell. **Experimental Study of the Specifications for Rods Used in Welding Cast Iron (Recherches expérimentales concernant les spécifications des baguettes pour la soudure de la fonte).** L. J. TIBBENHAM. For the best results welding rods for cast iron should contain 2.5-3.5% Si, as was determined by a comprehensive study. **Importance of Surface Quenching by Means of a Blow Torch (L'importance de la trempe superficielle au chalumeau pour l'industrie mécanique en général).** KESSNER. After reviewing the present methods for surface hardening the author studies the influence of speed of heating and cooling on the properties produced. The method is widely used in Germany. **Thermal Study of Oxyacetylene and Electric Welds (Etude thermique de la soudure oxy-acétylénique et à l'arc électrique).** A. PORTEVIN & D. SÉFÉRIAN. Heat distribution in a piece of metal heated locally to fusion can be determined theoretically. Experimental study of welds showed the direct dependence between the heat distribution and the method of welding (gas or electric), calorific properties of the metal and the shape and dimensions of the parts being welded. Quenching and other heat treating characteristics of the welds have to be examined in the light of these 3 groups of factors which permit the determination of the final properties of a weld by the use of curves determined experimentally. **Influence of Oxyacetylene Welding on the Mechanical Properties of Tubes Used in Aviation (L'influence de la soudure oxy-acétylénique sur les caractéristiques mécaniques des tubes pour les constructions aéronautiques).** G. CALBIANI. Describes a series of tests made on welded C and Cr-Mo steel tubes showing the independence of the total elongation of the useful section from the elongation of the welded zone. **Brazing With an Oxyacetylene Torch (La soudo-brasure par la flamme oxy-acétylénique).** A. B. KINZEL & A. R. LYTLE. Optimum conditions for obtaining sound joints are described. U. S. practice favors as brazing metals brasses containing either tin or iron, for example 59% Cu, 40% Zn, 1% Sn and 58 Cu, 40 Zn, 1 Sn, 1 Fe. **Influence of Small Cadmium Additions to the Deposited Metal for Copper Welding (De l'influence de l'addition de petites quantités de cadmium dans les métaux d'apport pour la soudure du cuivre).** LENO MATTEOLI. Welding with electrolytic Cu rods, Cu containing 0.1 Mn and 0.04 P or with Cu containing 0.9 Ag, and 0.04% P produces identical results. **Weld Resistance to Corrosion (Résistance des soudures à la corrosion).** A. LEROY & R. BONNOT. Bibliographic study. **Theory of Probabilities Applied to the Results of Mechanical Testing of Welds (Le calcul des probabilités appliqué aux résultats des essais mécaniques des soudures).** A. GOELZER. The results of a great many mechanical tests conducted by the author fall on a typical probability curve. He applies it to the study of electrodes and of the deposited metal. Several curves determined by him for different type of electrodes are given and compared with each other.

1 JDG (7b)

Electric Welding (La Soudure Electrique). R. GRANJON. *Electricité (Science et Industrie)*, Vol. 19, Apr. 1935, pages 176-177. General article. FR (7b)

Effect of Peening on Physical Properties of Welds and Stress Relief. O. M. HARRELSON. *Journal Amercan Welding Society*, Vol. 14, May 1935, pages 19-25. The use of a special, automatic, air operated peening hammer is described. The blow delivered by the hammer was calibrated and the effective blow varied and controlled by variation in air pressure. The welds studied were made with bare, light coated and heavy coated rods. Strain gage readings were made after welding double 90° V type joint. Physical tests are reported for weld metal, strain gage readings are tabulated and magnitude of the locked in stresses indicated in calculations from the strain gage readings. The use of the peening hammer relieves stress and improves physical properties and structure of the material.

2 WB (7b)

Progress in Electric Welding of Light Metals with Particular Consideration of Spot- and Seam Welding (Fortschritte der Elektroschweissung an Leichmetallen unter besonderer Berücksichtigung der Punkt- und Nahtschweissung). C. HAASE & O. PLASS. *Aluminium*, Vol. 17, Apr. 1935, pages 209-216. Reviews methods and equipment, discusses structural features and physical properties of spot- and seam welds; the mechanical properties are compared in the following table:

3

Kind of Weld	Material	Strength
Spot Welding. Fracture: shears at the spot or tears the spot from the sheet.	Al and medium strong alloys as silumin, pantal, aluman.	About 100% of tensile strength of hard sheet strips of 1 mm. thickness and width equal to the spot diameter.
	Alloys of high strength as duralumin, hydronalium.	About 85-100% of tensile strength of a strip as before.
Seam Welding. Fracture: tears in the sheet at the edge of the seam.	Spontaneously hardening alloys (duralumin, bondur) and hydronalium.	60-75% of tensile strength of hard sheet of 1 mm. thickness.
	Al and all other alloys and elektron.	50-60% of tensile strength of hard sheet of 1 mm. thickness.

4 5 Ha (7b)

Welding of Zinc Sheets (Schweissung von Zinkblechen). H. A. HORN. *Autogene Metallbearbeitung*, Vol. 28, June 1, 1935, pages 169-171. Experiments with oxy-acetylene welding of Zn showed that good welds are made with a flame adjusted to about 10% excess of O and to an acetylene consumption of 50-60 l./hr. for each mm. sheet thickness. Larger flames overheat the sheets and give too wide welding seams. The strength of the weld can be increased by slight hammering of the weld at 150° C. whereby the grain becomes finer. Microphotographs of good welds are reproduced.

6 Ha (7b)

All-Welded Oil Barge "Comor." A. J. LONGONI. *Commonwealth Engineer*, Vol. 22, Mar. 1, 1935, pages 243-247. The chief reason for the use of welding in the construction of the tank-tender "Comor" was the provision of oil-tight seams. Incidentally, certain savings in weight and cost have resulted from the use of this fabrication method. The general design is described and illustrated by means of drawings and the construction method is clearly set forth. An efficiency of 90% is claimed for the butt-welded joints. This is over 50% better than with single riveting and about 15% better than with double riveting.

7 WH (7b)

Securing the Maximum Life of Special Track Work. W. M. REID. *Mass Transportation*, Vol. 31, May 1935, pages 40-41. Special welding truck used with generating set of 400 amps. capacity for repairs on crossing points and switches. Salvage operations usually with Mn rod having a deposit of 12-14%.

WB (7b)

Electric Welding of Stainless Steel (Het electrisch lasschen van roestvrij staal). P. SCHOENMAKER & L. W. C. GAYMANS. *Polytechnisch Weekblad*, Vol. 29, Feb. 14, 1935, pages 97-101; Feb. 21, 1935, pages 113-115. Cross sections are presented showing the effect of 6, 8 and 18% Cr on the Fe-C constitutional diagram and of 2, 4, and 8% Ni on the 18% Cr cross section through the Fe-Cr-C system. Tables show analyses, heat treatment and physical properties of commercial Cr-Ni steels. The difficulties encountered in welding 18/8 are discussed and electric welding with "arosta" electrodes (analyses not given) is considered. Physical properties of 18/8 samples welded in different fashions are tabulated. A corrosion equipment for testing these specimens is illustrated and described and test results are reported.

8 WH (7b)

Welding Jobs in German Ship Yards I, II, III, IV (Aus deutschen Schiffbau Schweisswerkstätten I, II, III, IV). R. SCHMIDT. *Werft, Reederei & Hafen*, Vol. 16, Feb. 1, 1935, page 46; Mar. 1, 1935, page 77; Mar. 15, 1935, pages 89-90; Apr. 15, 1935, pages 115-118. A brief descriptive text accompanies this collection of some 60 representative photographs taken in the leading German shipyards with the object of demonstrating the great advances made in the use of welding in shipbuilding.

9 WH (7b)

Welded Bridges in Belgium (Les Ponts soudés en Belgique). A. SPOLIANSKY. *Revue Universelle des Mines*, Vol. 11, June 1935, pages 282-288. Examples of welding methods and design for greatest economy in material are given. Ha (7b)

10 **Shrinkage and Shrinkage Stresses During Electric Welding (De krimp en krimpspanningen bij het electrisch lasschen).** W. VAN BEELEN. *Polytechnisch Weekblad*, Vol. 29, Feb. 7, 1935, pages 81-82. Based on literature statements by Lottmann, Bibber and Ouwerkerk, the nature and reduction of shrinkage stresses set up during electric welding are discussed. WH (7b)

8. FINISHING

H. S. RAWDON, SECTION EDITOR

Attractive Finish Helps Metal Products Sales—32. Designing for Profits. HERBERT R. SIMONDS. *Iron Age*, Vol. 135, Feb. 28, 1935, pages 24-25, 68-71. Describes the principles used by industrial designers and how they may be adopted by small plants. First requisite is thorough knowledge of the material used. An important feature of design of metal products is the nature of the finish. VSP (8)

8a. Pickling

Precautions in the Use of Inhibitors in Electro-Galvanizing Processes (Was ist bei der Anwendung von Sparbeizen für elektro-galvanische Arbeiten zu beachten?) *Metallwaren Industrie & Galvano-Technik*, Vol. 33, Feb. 1, 1935, pages 51-52. No universally applicable inhibitor is available; laboratory tests for determining the usefulness of inhibitors are described. EF (8a)

8b. Cleaning, including Sand Blasting

Effect of Some Cleaning and Disinfecting Agents on Aluminum (Die Wirkung einiger Reinigungs- und Desinfektionsmittel auf Aluminium). *Aluminium*, Vol. 17, Apr. 1935, pages 222-223. The action of activine, alpurite, antiformine, brindisine, chloramine, neomoscan, lysol, P_3, P_3 aluco, and a few other commercial cleansing agents used in the household (as different soaps) is described. Most of them cause only little loss of weight or discoloration; the action of soaps can be obviated entirely by adding a little sodium silicate. Ha (8b)

8c. Polishing & Grinding

Grinding and Polishing of Aluminum and its Alloys (Schleifen und Polieren von Aluminium und seinen Legierungen). A. v. ZEERLEDER. *Aluminium*, Vol. 17, May 1935, pages 245-251. The facility with which a metal can be polished depends more on the uniformity, structure and properties of the individual crystals in the surface than on its hardness; a softer metal with fine, uniform crystal grain can be polished better than a harder metal of less uniform surface. A table gives the tensile properties of Al alloys. The velocities applicable for the various materials are discussed. Polishing agents, varnishes, and treatment are described. Ha (8c)

Grinding and Polishing of Light Metals (Das Schleifen und Polieren der Leichtmetalle). F. WEISS. *Oberflächentechnik*, Vol. 12, June 18, 1935, pages 151-152. Methods for rough grinding and finishing, wheels, materials and polishing agents for alloys of different hardness are described. Ha (8c)

8d. Electroplating

Studies in the Theory of Chromium Electrodeposition. RAYMOND R. ROGERS. *Electrochemical Society, Preprint* 68-1, 1935, pages 1-22. Author's abstract: "The theories which seem to apply to the deposition of the more noble metals from aqueous solutions do not apply in general to the base metals. Selecting the electrodeposition of Cr as a typical case, numerous experiments were carried out under widely different conditions. The results support the conclusions: (1) that the film of electrolyte in intimate contact with the cathode is more alkaline than the main body of the bath; (2) that this film must have a definite pH value for metal deposition to take place; (3) that the final reduction of Cr to the metallic state is due to atomic hydrogen and not to a mere electron exchange between cathode and positively charged metal ions; (4) that the amount of atomic hydrogen available at the cathode must be maintained within well defined limits. The theory developed undoubtedly has general application. Evidence is presented in support of the theory that even the most active metals may be electrodeposited from aqueous solutions." GBH (8d)

Diffusion on Copper Plated Zinc Base Die Castings. W. CASTELL. *Monthly Review American Electro-Platers' Society*, Vol. 21, Oct. 1934, pages 7-12. Zn base die castings cannot be heavily Ni plated from the ordinary "die cast" Ni solution. To obtain heavier deposits and better resistance to corrosion a regular Ni solution is used after a preliminary cyanide Cu plating. To prevent Ni plate from blistering due to absorption of underlying Cu by the Zn base metal some manufacturers require a minimum of .0005" Cu. In order to determine advisability of heavy Cu the author plated 4 samples with from .00007" to .00047" Cu and subjected them to temperatures of 220° and 450°F. for periods up to 4 weeks. After examining these for diffusion, and other similar specimens subjected to outdoor exposure for blistering, conclusion was reached that heavy Cu plate is unnecessary and that .0003" thickness is sufficient if subsequent Ni is at least .0006". Includes discussion. GBH (8d)

Chromium Plating with Solutions Containing Hydrofluoric Acid (Verchromung aus flusssäurehaltigen Chromsäurelösungen). K. ASSMANN. *Chemiker-Zeitung*, Vol. 59, Feb. 27, 1935, pages 177-178. A solution containing 350 g. CrO_3 and 3 g. KF/l., used at 3.8-4.0 volts and 4-6 amps./dm.^{2}, with electrodes 12 cm. apart, produces shiny Cr deposits at 18°-20° C. To obtain similar deposits in a sulphate solution the temperature would have to be 35°-40°. The throwing power of fluoride solutions is very good but the current efficiency, 9%, is lower than that of sulphate solutions, 14%. To allow for that the plating time must be increased 50%, but more uniform plating is obtained. CEM (8d)

8e. Metallic Coatings other than Electroplating

2 **Some Fundamental Considerations on Tinplate.** W. E. HOARE. *Sheet Metal Industries*, Vol. 9, Mar. 1935, pages 133-135, 137. A rather complete discussion of the nature and properties of the compound $FeSn_2$. AWM (8e)

Metallizing an Important Factor in Prevention of Corrosion in Refineries. H. R. LELAND. *Metallizer*, Vol. 3, May 10, 1935, pages 4-5, 10. Blisters may form in metallized surfaces if oil is not completely removed from porous areas and welds. Oil should be driven out by heating as with a torch before spraying. Al linings for reaction chambers should be 0.018" in thickness. In repairing plungers, piston rods, pump outfits and pistons a surface hardness of over 400 Brinell is obtained by spraying steel of 1.2% C. Descriptions of many specific applications of metal spraying in various refineries are given. BWG (8e)

3 **Improved Lining for New Refinery Vessels.** L. E. KUNKLER. *Metallizer*, Vol. 3, Feb. 28, 935, pages 2-3, 8. Laboratory tests made by various organizations, have shown the desirability of lining new oil refinery vessels with Al by metal spraying before they are heat treated for stress relief. A 15% H_2SO_4 immersion test indicated that an extended life on the order of 10 times the life of linings applied after vessels had been in service could be secured by a calorizing treatment. The welded structure is cleaned after fabrication, sprayed with 0.015 to 0.020" of Al, the lining covered with two coats of water glass and the whole heated at least 2 hours at 1100° to 1200° F. A treatment of 1 hour at 1200° F. gave an Al penetration depth of 0.006". BWG (8e)

4 **Protecting Machine Parts by Metal Spraying.** HAROLD B. VEITH. *Machine Design*, Vol. 7, Feb. 1935, pages 28-29. Discusses the practical application of sprayed metal coatings (1) the spraying of pipe coil with an 0.01" Al coat to prevent it from contaminating a vegetable oil product (cost of spraying = 18 cents/ft.^{2}; Al wire consumption in gun = 4-7 lbs./hr.). (2) Spraying of cheese mixing tank with Sn (0.015") and intermediary layer of Zn (0.003"). The outer Sn coat is polished. (3) Spraying of Fe impellers and pump cases with combinations of Monel (0.01") and Sb-Pb (0.01"). (4) Spraying of conveyor press for fruit industry with 0.04" stainless steel coating. WH (8e)

5 **Builder Upper.** E. J. TANGERMAN. *Power*, Vol. 78, Dec. 1934, pages 661-663, 700. Sprayed-metal coatings are discussed, together with selection of metal, method of application, uses and costs. AHE (8e)

8f. Non-Metallic Coatings

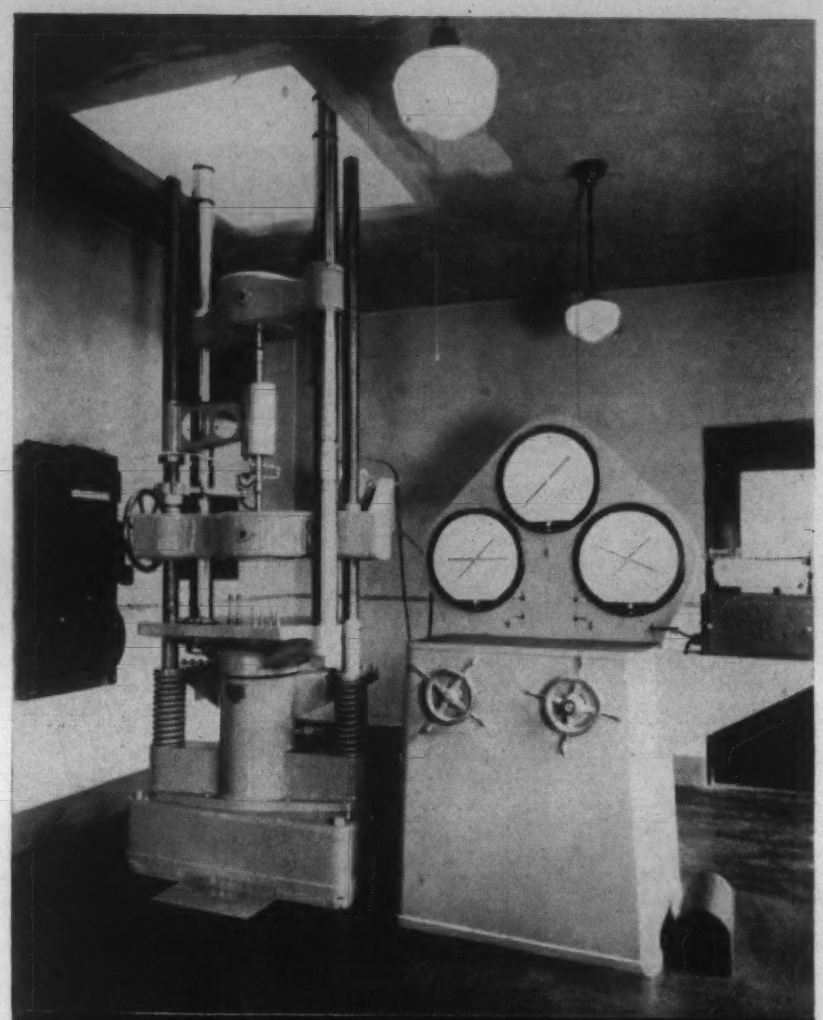
6 **Celluloid is used by Pipe Line to Combat Corrosion and Stress.** L. E. BREDBERG. *Oil & Gas Journal*, Vol. 33, Mar. 14, 1935, pages 13, 32. Cellulose nitrate plastic is being used experimentally for coating pipe. It is shipped in rolls of sheet 0.010" thick. The tensile strength is 8,000 lbs./in.^{2}; it is brittle at —20° F. and softens at 220° F. When softened it will expand 5% by vol. and when hardening will shrink 12%. Exposure to sunlight will cause it to check, crack and break, hence is restricted for covering underground pipe. VVK (8f)

7 **Metal Coloring with Molybdate Solutions (Metallfärbungen mit Molybdatlösungen).** H. KRAUSE. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle*, Vol. 8, Mar. 1935, pages 138-143. Besides the known methods of producing brown to black deposits on metals by electrolytic processes from Mo solutions, immersion processes give good results. Molybdate colorings take best effect on Zn. Black is easiest to obtain. With an addition of chloride, it is suitable for Al. Fe assumes only a fine, dark brown color. Cd, Sn, Pb and Pb alloys assume slightly iridescent brown or gray tones. The principal baths are (1) a solution of 5-20 g. ammonium molybdate in 1 l. made slightly ammoniacal with ammonia, and (2) ammonium molybdate solution of concentration as in (1) with half, or at most, the same amount of sodium thiosulphate in place of ammonia. The various processes, partly protected by patents, were examined with respect to their efficacy and the influence of additions of oxalic acid, fluorides, chlorides and silicates investigated. All colorings stood the bending test well on the tensile side of the bent strip while on the compression side they sometimes came off. Ha (8f)

8 **The Eloxal Process (Das Eloxal-Verfahren).** G. ELSSNER. *Oberflächentechnik*, Vol. 12, Mar. 19, 1935, pages 67-72. Characteristic properties and production of electrolytic oxide coatings on Al and its alloys are discussed comprehensively and the development of the process to reinforce and strengthen the oxide film which forms on Al on contact with air and water is described in detail. Anodic oxidation is the counterpart to electroplating; while the latter process builds a deposit on the cathode surface and increases the thickness, the oxide layer produced by the anodic (eloxal) process grows by converting part of the basis material (anode) into oxide. The chemical formation of the oxide film is explained and mechanical and electrical properties of eloxal layers described. The industrial importance of the process for increasing the use of Al and Al alloys is discussed. Ha (8f)

9 **How Attractive Finish Helps Metal Products Sales.—33. Porcelain Enameling of Small Parts.** HORACE R. WHITTIER & HERBERT R. SIMONDS. *Iron Age*, Vol. 135, Mar. 14, 1935, pages 14-17, 69. Describes method of finishing and enameling watch and clock faces, instrument dials, electric switch parts, etc., at the plant of Horace R. Whittier Co. VSP (8f)

10



One of the first installations in this country of high-temperature stress-strain recording is illustrated above.

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9. TESTING

1 **Electrolytic Determination of Titanium, Zirconium or Aluminum in Chromium Steels and Alloys.** H. A. Kar. *Metals & Alloys,* Vol. 6, June 1935, pages 156-157. Describes the method of and equipment for the electrolytic separation of Fe, Mn, Cr, Co, Ni, Mo, Sn and Cu preventing interference in the subsequent determination of Ti, Zr or Al. WLC (9)

2 **The Royal Society's Conversazione.** *Engineer,* Vol. 159, May 10, 1935, pages 485-486; *Engineering,* Vol. 139, May 10, 1935, pages 499-500. Briefly describes various exhibits set up at Burlington House, London, among which was that of the Metropolitan-Vickers Electrical Company, Limited. This consisted of apparatus for the detection of cracks in steel or other magnetic material. Sir Robert Hadfield demonstrated the use of the petrological microscope for the examination of steel-furnace slags. LFM (9)

9a. Inspection & Defects, including X-Ray Inspection

C. S. BARRETT, SECTION EDITOR

3 **Electro-Acoustical Testing of Welds (Elektroakustische Schweissnahtprüfung).** *Elektrizitätswirtschaft,* Vol. 34, Mar. 15, 1935, pages 186-187. The pros and cons of drill tests, X-raying and magnetic inspection of welds are reviewed. The new apparatus employs a "soldering copper" incorporating a feeler coil in its top and a vibration magnet in the handle. The weld is first magnetized by an ordinary magnet. Then the "soldering iron" is zigzagged along the weld. The alternating current induced in the test coil passes through a tube rectifier into ear-phones. The whole equipment weighs about 70 lbs. and can be applied to para-magnetic materials. It is also utilized in rolling mills for detecting defects and slag inclusions in high-grade rolling material and also detects cracks in pressed sheets. WH (9a)

4 **A Simple Means for Measuring the Temperature of Aluminum Blocks (Ein einfaches Mittel zur Temperaturmessung an Aluminiumblöcken).** A. v. Zeerleder. *Aluminium,* Vol. 17, Apr. 1935, pages 199-201. Two short wires of Cr and Ni-Cr respectively are inserted in handles isolated from each other so that the points project. These points are simply pressed into the surface of the block to measure its temperature so that the oxide film is pierced. The wires are connected in the usual manner to a galvanometer. Calibration and inertia curves of some thermocouples are given to show how long contact must be maintained to obtain the correct temperature. This is important in routine measurements during operation. Ha (9a)

5 **The X-ray Inspection of Magnesium Castings.** N. C. Hypher. *Metallurgia,* Vol. 11, Apr. 1935, pages 151-153. Defects in Mg castings are difficult to detect by radiography because of the low density of Mg. Defects can be detected readily if the casting is subjected to pressure so that a substance more opaque to X-rays is squeezed into its blowholes and porous places. The impregnation likewise stops up the leaks. JLG (9a)

6 **A Method for Detection and Evaluation of Residual Distortion in Crystals with Special Reference to Electric Steel.** George L. Clark & M. M. Beckwith. *Zeitschrift für Kristallographie,* Vol. 90, May 1935, pages 392-398. In English. In the process of the first stages of cold working an Fe-Si electric steel, there is a periodicity of the occurrence of the phenomena of fragmentation which was found (under the conditions used) to have a value equal to approximately 3.3% reduction. A quantitative measurement of the amount of residual distortion as indicated by X-ray diffraction patterns was devised. The degree of perfection of the grains was indicated by a modulus M which was calculated from the diffraction patterns by a formula. The value of the modulus under the experimental conditions used was found to be 1.00 for as nearly perfectly annealed crystals of Si-steel as have ever been found possible in the laboratory. Any value for M greater than this value denotes residual distortion and the numerical difference is the quantitative measurement of that residual distortion. Magnetic permeability seems to be influenced proportionally by residual distortion. Representative magnetometer curves for specimens with moduli of 1.00 and 1.89 (the latter one of the best commercial grades) are illustrated. Specimens with intermediate moduli have also intermediate magnetic values. EF (9a)

7 **Elektron Microscope and Its Utilization, Especially for the Study of Thin Layers on Metals (Das Elektronenmikroskop und seine Anwendung, insbesondere zum Studium von dünnen Schichten auf Metallen).** E. Brüche. *Kolloid Zeitschrift,* Vol. 69, Dec. 1934, pages 389-394. Paper before the 10th General Meeting of the Kolloid Gesellschaft, Hanover, Sept. 1934, discusses and illustrates the structural details of an electron microscope and microstructures taken therewith. Emphasizes the fact that the electron microscope is suited for bringing out the grain boundaries as well as the grain areas. The advantages of the electron microscopic examination is that an actual etching is not necessary. Thus transformations in a metallic material can be observed directly and tests are under way to study the $\alpha \longrightarrow \gamma$-Fe transformation. The grain growth of Fe has been investigated at 1000° C. A new development aiming at widening of the scope of utilization is the use of ultraviolet light in addition to electron rays at lower temperatures. EF (9a)

8 **Focussing Camera for the Back Reflection Method (Eine Sammelkammer für das Rückstrahlverfahren).** F. Wever & Adolf Rose. *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung, Düsseldorf,* Vol. 17, No. 3, 1935, pages 33-37. The advantages of measurement of internal stresses in metals by the method of reflected X-rays are explained and a camera is described in which the rays are focussed in such manner that the usual exposure time of several hours could be reduced to 5-10 min. without loss of accuracy. Ha (9a)

Present State of X-Ray Technique as Applied to the Evaluation of Materials and Joints (Allgemeiner Überblick über den heutigen Stand der Röntgentechnik für die Beurteilung von Werkstoffen und Werkstückverbindungen). HERMANN HELLMICH. *Elektrizitätswirtschaft*, Vol. 7, May 5, 1935, pages 279-283. Paper before the Reichsverband der Elektrizitäts Versorgung Mar. 14, 1935, points out the latest advances in X-ray inspection and shows in 14 representative illustrations the possibilities of this testing method. The introduction of heavy metal filters, intensifier screens, improved films and standardization methods is stressed. The latest Zn-sulphide screens raised the intensity 5 times. Three diagrams show the progress during the last 5 years with reference to film efficiency, intensities of screens and limits of detecting defects by means of X-rays. With screens, a maximum thickness of 10 mm. and 40 mm. can be safely inspected on steel and Al respectively. WH (9a)

Interior Defects Revealed by X-ray. F. K. ZIEGLER. *Metal Progress*, Vol. 27, June 1935, pages 45-48. Discussion of application of X-rays to inspection of castings. Illustrated with radiographs and fractured sections. WLC (9a)

Status and Development of Material Testing without Destruction (Stand und Entwicklung der zerstörungsfreien Werkstoffprüfung). R. BERTHOLD. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Apr. 20, 1935, pages 477-484. Testing with X- and γ-rays, magnetic testing, the apparatus required, principles of the methods and practical evaluation of photographs are discussed. 44 references. Ha (9a)

Possibilities and Limits in X-Raying Wide Fields (Möglichkeiten und Grenzen der Grossbildaufnahmen mit Röntgenstrahlen). R. BERTHOLD. *Archiv für das Eisenhüttenwesen*, Vol. 8, Mar. 1935, pages 425-426. Wide fields are X-rayed by setting the tube at a distance from the object. Welds and different thicknesses of steel were examined to see how clearly defects could be distinguished with the object near and far from the tube. By the use of an intensifying screen the object distance could be increased from the usual 50 or 70 cm. to 3 and 4 m. and still permit radiographs of good clarity; 200 to 250 kv. tubes were used. SE (9a)

Applicability of Very Hard X-Rays for Radiography (Die Verwendbarkeit sehr harter Röntgenstrahlen bei der Werkstoffdurchleuchtung). A. HERR. *Elektrotechnische Zeitschrift*, Vol. 56, Apr. 11, 1935, pages 425-428. Voltages up to 800,000 volts are used for examining material in finished structures, machinery. Steel requires 200,000 v. for 80 mm. thickness and 300,000 for 120 mm. Testing apparatus, methods and advantages are described. Ha (9a)

Surface Inspection and Quality Improvement in Metal Plating Industries (Oberflächenprüfung und Qualitätssteigerung in den Metallveredlungs-Industrieen). A. KARSTEN. *Metallwaren Industrie & Galvano Technik*, Vol. 32, Dec. 15, 1934, pages 537-539. Description of a new microscope of the E. Busch-Company, Rathenow, intended for the inspection of metallic surfaces. EF (9a)

Surface Cracking in Forged Shaft & Axle Journals. H. H. ASHDOWN. *Metal Progress*, Vol. 27, May 1935, pages 29-33. Describes investigation of cracking on journals of shafting and axles of 1.27% Ni, 0.33% C steel. Cracks have appearance similar to grinding cracks and are attributed to like causes: heavy surface stresses caused by heavy load, high peripheral speed and frequent heavy brake action. WLC (9a)

Grinding Cracks, How They Look, How to Avoid. ADAM M. STEEVER. *Metal Progress*, Vol. 27, May 1935, pages 52-53, 68. The appearance of this type of defect is illustrated; the author recommends light grinding cuts with a soft wheel. WLC (9a)

Steel Inspection Methods and Their Limitations W. E. JOMINY. *Iron Age*, Vol. 135, Apr. 11, 1935, pages 8-9, 59-63. Discusses steel inspection tests commonly used as well as others not so common. Includes description of methods of examining steel for automotive applications, including bars for ring gears and flat leaf chassis springs and wire for coil springs. States that present methods of testing are inadequate and that new methods are needed. VSP (9a)

Material Inspection. E. R. GADD. *Journal Institution of Production Engineers*, Vol. 14, Mar. 1935, pages 118-140. Includes discussion. Possible defects which may arise in melting, casting, working, and heat-treating a typical steel are discussed. The inspection procedure followed by aircraft manufacturers in inspecting raw material, machine components, and finished parts is outlined. JCC (9a)

Nature of Shatter Cracks. R. E. CRAMER. *Metal Progress*, Vol. 27, June 1935, page 68. Discussion of confusion of terms. WLC (9a)

Fissure Data Show New Trends. *Railway Engineering & Maintenance*, Vol. 31, Apr. 1935, pages 230-231. A detailed statistical analysis of large-scale fissure determinations in rails by means of the Sperry detector car. WH (9a)

Utilization of Electrical Resistance Measurements for Controlling the Composition of Alloys. EARLE E. SCHUMACHER & LAWRENCE FERGUSON. *Metals & Alloys*, Vol. 6, June 1935, pages 150-152. 4 references. Describes the correlation of electrical resistance of Pb-Sb alloys and Sb content and the use of such measurements for control of composition of this alloy in production. Range 0.40-1.10% Sb was studied and accuracy of resistance method of analysis is equal or superior to wet methods. Suggests application of same measurements to analytical control of other alloys. WLC (9a)

Observations on Flaking of Steels (Alcune osservazioni sui fiocchi negli acciai). A. SCORTECCI. *La Metallurgia Italiana*, Vol. 27, Apr. 1935, pages 275-279. A summary of the causes. AWC (9a)

A New Microscope for Testing Surfaces (Über ein neues Mikroskop zur Oberflächenprüfung). G. SCHMALTZ. *Zeitschrift für Instrumentenkunde*, Vol. 55, Jan. 1935, pages 38-39; *Zeiss Nachrichten*, 1934, No. 7, pages 6-12. A formerly designed instrument checking the surface roughness by means of a needle passed across the work was found to be too complicated for shop inspection. The new optical method permits exhibiting and photographing the profile curve of a surface. The underlying principle of the new microscope developed by the Carl Zeiss Co., Jena, is illustrated. EF (9a)

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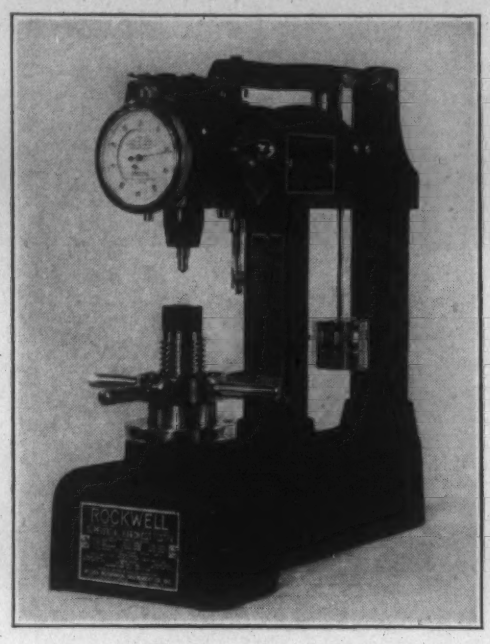

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Photo-Electric Measurement of the Diameter of Thin Wires (Die lichtelektrische Messung des Durchmessers feiner Drähte). RICHARD C. SCHMIDT. *Zeitschrift für Instrumentenkunde*, Vol. 55, Mar. 1935, page 137; *Elektrotechnische Zeitschrift*, Vol. 55, 1934, pages 785-786. A method was devised to control the gage of thin wires without necessitating cutting out a sample. By optical means an 160 x magnification is obtained by means of a photocell. The measuring range is from 0.02-0.5 mm. EF (9a)

9b. Physical & Mechanical Testing

W. A. TUCKER, SECTION EDITOR

Tensile Strength Testing of Cast Iron. A Critical Review and a Suggestion (Die Festigkeitsprüfung von Gusseisen. Eine kritische Betrachtung und ein Vorschlag). B. OSANN. *Giesserei*, Vol. 22, Apr. 12, 1935, pages 169-172. The history of cast Fe is outlined. The formula for calculating strength, $K = 24(Si \pm I \times 0.7/Si)$ kg./mm.², is now commonly applied; Si is Si content in %, I is an index number showing whether the casting is eutectic or not, + being used for hypoeutectic, — for hypereutectic structure; it is 0 for eutectic structure. It is shown that any desired value of tensile strength can be obtained if the foundry is at liberty to select material and dimensions of the test specimens. A suggestion is made for molding and casting test specimens which do not require machining which might falsify results. Ha (9b)

The Resistance of Spring Steels to Repeated Impact Stresses. G. A. HANKINS & H. R. MILLS. *Iron & Steel Institute*, May 1935, Advance Copy No. 4, 11 pages. A Cr-V steel and 2 Si-Mn steels were tested. These were tested both with the original surface and with a polished surface containing no decarburized layer. Tests were made on un-notched specimens 5x10x60 mm. in a modified Stanton machine. The specimen was not turned and the impact was from one side only. Tests were run up to one million blows. The irregular decarburized surface which is present on a normal heat-treated spring produces a low repeated impact endurance limit (10^6 impacts) in the same manner as it produces a low endurance fatigue limit. The irregular decarburized surface does not appear to have any influence on the resistance of a large impact of magnitude approaching the full single-blow impact strength of the plate. The "graphite" treatment described in an earlier paper may also be useful for improving resistance to repeated impact. In general, the results show that with the repeated impact the results obtained by a very small number of impacts are indicative of the single-blow test but that the repeated impact endurance limits correspond to the results of cyclic endurance test. 5 references. JLG (9b)

The Design and Equipment of Photo-Elastic Laboratories. E. G. COKER. *Engineering*, Vol. 139, Feb. 15, 1935, pages 183-185. Abridged from paper delivered before the Junior Institution of Engineers, Feb. 14, 1935. Describes the various pieces of apparatus necessary for equipping a photo-elastic laboratory. VSP (9b)

1 **Investigations of Methods Suitable for Determining the Hardening Depth of Tool Steel (Undersökning angående lämpligt förfaringssatt for bestämning av härdjupet hos verktygsstål).** GUNNAR THALEN. *Jernkontorets Annaler*, Vol. 114, Mar. 1935, pages 99-134. Fracture grain size of quenched specimens and depth of hardening are 2 properties which, in addition to chemical analysis, are useful for judging tool steels. The present investigation indicates that hardening depth may be defined as the thickness of the surface layer, measured from the edge to the point where the structure contains equal quantities of martensite and troostite. This may be determined by etching 10-15 seconds with a 2% solution of HNO_3 in alcohol to darken the core. The distance from the edge of the fracture to the boundary line where the transition from the surface layer to the core is most plainly discernible may be taken as the depth of hardening. Cylindrical test pieces, turned and smoothly finished, with a diameter of 22 mm. are most suitable. The condition of the surface of the test piece was found unimportant although the hardening depth is somewhat greater for polished than for planed surfaces. Heating in lead baths also gives greater depth than muffle furnaces and salt baths. The hardening depth also increases with rising temperature, and in general a high grain fracture value is characterized by a low hardening depth. Curves are given showing the relation between hardening depth and "hardenability" as defined by Shepherd (*Transactions American Society Steel Treating*, Jan. 1930). HCD (9b)

2

3 **Photoelastic Tests Require Care in Preparing Specimens.** T. V. BUCKWALTER, O. J. HORGER & S. MAULBETCH. *Steel*, Vol. 96, June 3, 1935, pages 31-32. In making photoelastic study of press fits, rectangular specimens are cut from polished bakelite sheets, allowing $\frac{1}{8}$"-$\frac{3}{16}$" more than overall dimensions on all edges. Material is placed on plate of glass slightly larger than specimen, with glazed paper between. Assembly is placed in center of electric furnace controlled by thermocouple and furnace is sealed against drafts. When temperature reaches 85° C., automatic cooling mechanism is started. In 17-20 hrs., temperature is down to within 10° of room temperature, after which regulation is disconnected and furnace allowed to finish cooling normally. After annealing, specimen is machined to within 0.003 in. of size, using fine feed and light cut. Annealing is necessary after machining. If specimen can be filed or lapped to size, this annealing may be omitted. If annealed specimen shows fine bright line around edges when examined under polarized light, it is re-machined lightly to remove this. It is finished to size using light feed with great care. Photographs are taken 5 min. after application of load. MS (9b)

4

The Testing of Castings. FRANCIS W. ROWE. *Metallurgia*, Vol. 11, Apr. 1935, pages 163-164. Separate test bars or cast-on bars cannot be taken as representative of the properties of a casting. The true properties of a casting can be determined only by testing a sample cut from the casting itself. Tests on P-bronze castings are given to prove the unreliability of tests on separately cast bars. JLG (9b)

5 **Measurement of Thermal Conductivity of Aluminum Alloys (Messungen der Wärmeleitfähigkeit von Aluminium-Legierungen)** G. EURINGER & H. HANEMANN. *Metallwirtschaft*, Vol. 14, May 17, 1935, pages 389-391. An improved apparatus is described in which small specimens, 10 cm. long, 1 cm. diam. can be used. Measurements were made between 80° and 170° C. and between 170° and 260°. The conductivity is slightly higher in the higher range, and it is about 10% higher in the annealed than in the as cast and heat treated states. While pure Al has a conductivity of .540 cal./sec./cm./°C., the alloys range from .310 to .393. A small amount of alloying element

6 lowers the conductivity about as much as a large amount. Mg lowers the conductivity more than other elements, probably because of the formation of Al-Mg solid solution. Bars of the same composition having 4% difference in sp. gr. due to porosity had 8% difference in conductivity. CEM (9b)

Load-Carrying Capacity of an Excentrically and Transversely Loaded Test Bar Made of Ideal Plastic Steel (Die Tragfähigkeit des exzentrisch beanspruchten und querbelasteten Druckstabes aus einem ideal plastischen Stahl). KARL JEZEK. *Sitzungsberichte der Akademie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Klasse, Sect. II a, Mathematik, Astronomie, Physik, Meteorologie & Technik*, Vol. 143, No. 7, 1934, pages 339-366.

7 Some 83 mathematical formulae are set forth covering an analytical solution of the equilibrium problem of test bars loaded eccentrically and transversely by a single load. The derivations for an ideal-plastic steel are transferred to test bars of the standard structural steel St 37. Taking the effect of strain hardening into account, critical stresses are computed with reference to different bar dimensions. WH (9b)

Photo-Elastic Study of Stresses Due to Impact. ZIRO TUZI & MASTAKE NISIDA. *Scientific Paper Institute of Physical & Chemical Research*, Tokyo, Vol. 26, Apr. 1935, pages 278-309. In English. High-speed kinematography of photo-elastic fringes was developed with the object of analyzing quick variations of internal stresses set up by vibrations or impacts. As the light source, an ordinary C arc lamp fed with high currents and red filters of a very narrow band were utilized. The investigations were restricted to certain

8 sections and exposure times of 1/5,000-1/50,000 sec. were used. Phonolite samples (cantilever, beam, rings) were studied. The experimental results are compared with theoretical derivations based on the theory of shock phenomena. The range of coincidence between theoretical and experimental results is critically discussed. Regarding maximum impact stresses, 80-90% of the calculated values was

9 obtained. WH (9b)

Freezing Point of Rhodium (Der Erstarrungspunkt von Rhodium). WM. F. ROESER & H. T. WENSEL. *Zeitschrift für Instrumentenkunde*, Vol. 55, Apr. 1935, pages 181-182. Tests in the Bureau of Standards on the freezing point of Rh containing less than 0.01% impurities yielded 1966° ± 3° C. See *Metals & Alloys*, Vol. 4, Dec. 1934, page MA 575. EF (9b)

10 **Determination of Fineness of Silver Alloys by Scratch Test (Die Bestimmung des Feingehalts von Silberlegierungen durch Strichprobe).** K. BIHLMAIER. *Mitteilungen des Forschungsinstituts und Probieramts für Edelmetalle*, Vol. 9, May/June 1935, pages 22-24. A quantitative Ag scratch test consists in comparing the color of the scratch of the unknown alloy with that of alloys of known definite Ag content. The scratch needles are Ag-Cu alloys with different, exactly known Ag content. The method is described in detail. Ha (9b)

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9c. Fatigue Testing

H. F. MOORE, SECTION EDITOR

The abstracts appearing under this heading are prepared in cooperation with the A.S.T.M. Research Committee on Fatigue of Metals.

The Reasons for Improvement in Endurance Limit from Working the Surface (Die Ursachen, auf die die Steigerung der Dauerhaltbarkeit durch das Oberflächendrücken zurückzuführen ist). O. Föppl. *Mitteilungen des Wöhler-Instituts*, No. 25, 1935, pages 52-61. General discussion as to whether compression of the surface raises the endurance limit through cold working of the surface, as previously argued by Föppl or by the introduction of unrelieved stresses, as claimed by Thum. No new data. HWG (9c)

Fatigue of "Superharmonic" Steel Helical Springs (I fenomeni di fatica nelle molle ad elica in acciaio "superarmonico"). V. Prever & L. Locati. *La Metallurgia Italiana*, Vol. 27, Mar. 1935, pages 188-204. A fatigue test has been developed for testing valve spring steels in which the spring is straightened out and then given a torsion test, the metal being twisted back and forth through a certain angle until it fails. Comparative tests with springs in actual use confirm the conclusion that satisfactory springs must not be too stiff. AWC (9c)

Possibilities of Spectroscopy (Les Possibilités de la Spectroscopie) P. Swings. *Revue Universelle des Mines*, Vol. 11, June 1935, pages 276-280. The great importance of spectroscopy in the discoveries of atomic and molecular physics, in metallography and analytical chemistry is outlined and illustrated by a few examples in determining impurities in so-called pure metals or products, in its application to archeological problems and in the determination of minerals. Ha (9c)

9d. Magnetic Testing

L. REID, SECTION EDITOR

The Coercive Force of Magnetite Powders. V. H. Gottschalk. *Physics*, Vol. 6, Apr. 1935, pages 127-132. A large amount of coercive force data is presented for magnetic measurements on sized powders of a number of purified magnetites. A simple quantitative relation between evoercive force and specific surface is shown in a curve. The coercive force of the powder increases linearly as the mean specific surface is increased by grinding. This is in agreement with dispersion theory of magnetic hardening held by Bureau of Mines. Magnetism is considered to be related to electron spin and conduction electrons are believed to have no influence. The equation given by author does not fit all published data on the variation of coercive force with grain size in ferrous alloys but reference is made to literature on relation between hysteresis loss and grain size in which there is agreement that grain size does affect hysteresis loss and coercive force. No satisfactory explanation for the effect is available. WB (9d)

9e. Spectrography

6 **The Arc and Spark Spectrum of Pure Iron as Means for Qualitative Emission Spectrum Analysis; Testing of Iron Alloys (Das Funken- und Bogenspektrum des reinen Eisens als Hilfsmittel der qualitativen Emissionsspektral-analyse; Untersuchung von Eisenlegierungen)** H. Hammerschmid, C. F. Linström & G. Scheibe. *Mitteilungen aus den Forschungsanstalten des GHH-Konzerns*, Vol. 3, June 1935, pages 223-229. A spectrum of a very pure carbonyl Fe was prepared which served to analyze Fe and Fe alloys by determining the wave length of an unknown element from the location of an unknown line between known lines of the Fe spectrum and thus the respective element. Constituents down to about 0.01% can be determined. Tables show the minimum concentration which can be detected with reliability and include, besides the more common alloying elements, also some rarer elements as Ge, As, Ga, Sb. Ha (9e)

7 **Bohn Employs Spectrograph in Analysis of Non-ferrous Ingots.** *Automotive Industries*, Vol. 72, Apr. 27, 1935, pages 575-576. Application of spectrograph in analysis of bearing metals, wrought Al alloys, etc. is described. BWG (9e)

8 **Spectrum Analysis: Its Role in the Examination of Ore-Concentrates, Metals and Alloys.** *Mining Journal*, Vol. 186, Nov. 3, 1934, pages 819-820. A review. AHE (9e)

Quantitative Spectroscopy and Its Analytical Applications. S. Judd Lewis. *Analyst*, Vol. 60, Jan. 1935, pages 10-17. The accuracy of the process is discussed. AHE (9e)

9 **Spectra of Hafnium and Tungsten (La estructura de los espectros del hafnio y del tungsteno).** Adolfo T. Williams. *Anales de la Sociedad Cientifica Argentina*, Vol. 118, Aug. 1934, pages 88-91. The quantum numbers R and L of 11 terms of Hf (I), 8 of Hf (II) and 15 of W (I) have been established. The evaluation method used will be found useful in many cases. EF (9e)

The Classification of the First Spectrum of Lead. Lester T. Earls & Ralph A. Sawyer. *Physical Review*, Vol. 47, Jan. 1935, pages 115-122. The spectrum of Pb as excited in a Schuler hollow cathode discharge in He has been photographed in the region from 800 to 10,000 A.U. 247 lines have been classified. WAT (9e)

10 **The Zeeman Effect of the Spectrum of Arsenic.** J. B. Green & W. M. Barrows, Jr., *Physical Review*, Vol. 46, Jan. 1935, pages 131-135. Zeeman patterns of the spectrum of As have been measured. The results are in general agreement with perturbation theory. WAT (9e)

10. METALLOGRAPHY

J. S. MARSH, SECTION EDITOR

Structural Investigations of Boundary Layers by Means of X-rays and Electrons (Strukturuntersuchungen von Grenzschichten mittels Röntgenstrahlen und Elektronen). E. RUPP. *Kolloid Zeitschrift*, Vol. 69, Dec. 1934, pages 369-376; discussion, pages 377-378. A special chapter of this paper presented before the 10th General Meeting of the Kolloid Gesellschaft, Hanover, Sept. 1934, deals with electron diffraction on polished metal surfaces which apparently furnishes a link between the liquid and solid state. Electron interference pictures from highly polished surfaces exhibit 2 new indistinct rings which are not connected with the structure. These rings were found on cubic face-centered lattices (Au, Ag, Cu, Pb) as well as on cubic body-centered and non-cubic metals. (Ni, α-Fe, Cd, Mo, Cr, Bi, Sb, Zn, Te). Beilby's microscopic evidence is thus corroborated, viz. that polishing transfers the surface layers into a semi-liquid state. Highly polished surface layers do not conduct the electric current. It is shown that there is not a chaotic arrangement of atoms in liquids and that the mean atomic distance in the highly polished surface layer of metals is 2.84-2.95 A.U. irrespective of their lattice type. Condensation tests of metals on polished metallic surfaces prove that the latter behave like an undercooled liquid. Diffraction pictures from Zn deposited from the vapor state on etched and highly polished Cu are shown. The first Zn crystals are dissolved in the latter "like snow flakes in water." Zn deposited on highly polished Cu adheres intimately, contrary to Zn condensed on ordinary Cu sheet. Electron interference pictures from protective films formed on Al in dry or moist air or pure O yielded a new ϵ-Al_2O_3 structure which is not identical with the 4 Al_2O_3 structures known so far. The thinnest rust layers are built up by the "open structure" of γ-FeOOH. Passive Fe exhibits the close-packed α-Fe_2O_3 structure. It is possible that the close-packed arrangement of O ions raises the corrosion resistance by passivation whereas the open structure of rust through which O can easily migrate permits the Fe to be attacked. Electron diffraction diagrams from differently treated Ni surfaces are shown and the "loosening-up" of the Ni lattice by H and N is discussed. EF (10)

The Selection of a Suitable Method of Polishing Cast Iron for Microscopic Examination. M. F. SURLS. *Transactions American Foundrymen's Association*, Vol. 6, Apr. 1935, pages 289-307. The development of a polishing procedure for cast Fe is explained and the principles underlying the present procedure are outlined. Regardless of the method used the final success depends largely on the skill and experience of the operator. The author found that a satisfactory method for general work involves the use of emery papers for the intermediate steps and a finish with rouge. A polishing stand is recommended which is of such design that the disks will run true and without vertical or lateral vibration. CEJ (10)

Structure of Rolled and Drawn Zirconium (Walz- und Zugtextur von Zirkonium). W. G. BURGERS & F. M. JACOBS. *Metallwirtschaft*, Vol. 14, Apr. 12, 1935, pages 285-287. X-ray investigations disclose that drawn Zr wire has a ring fiber structure with the base plane parallel to the wire axis. Rolled Zr sheet has a base plane parallel to the rolling plane. The structures are similar to those of Mg. 10 references. CEM (10)

The Dissolution Velocity of Graphite in Liquid Iron (Ueber die Auflösungsgeschwindigkeit des Graphits im flüssigen Eisen). E. PIWOWARSKY. *Giesserei*, Vol. 22, June 7, 1935, pages 274-277. Experiments proved that graphite dissolves in liquid cast Fe so quickly that no undissolved graphite particles can be active in the crystallization of the graphite. Ha (10)

Crystal Structure of Au_2Bi. T. JURRIAANSE. *Zeitschrift für Kristallographie, Kristallgeometrie, Kristallphysik & Kristallchemie*, Vol. 90, Apr. 1935, pages 322-329. In English. Compound Au_2Bi was previously detected (M. J. DE HAAS & T. JURRIAANSE. *Proceedings Royal Academy of Amsterdam*, Vol. 35, 1932, page 748.) in the Au-Bi system at 66.6 at. % Au. The constitutional diagram of Vogel (*Zeitschrift für anorganische & allgemeine Chemie*, Vol. 50, 1906, page 147.) is modified. The homogeneity range on the Au side is less than 0.2% (instead of 4%). According to X-ray data, Bi does not dissolve in Au at all, and none of the components dissolves in Au_2Bi. The crystal structure of Au_2Bi is face-centered cubic with an atomic arrangement 8f-16c and space group O^7_h. This intermetallic compound has the same structure as Cu_2Mg, Au_2Pb, W_2Zr, Bi_2K, $CuBe_2$, and MgNiZn. The ratio of the atomic radii of the constituent atoms is fairly constant for these compounds. The melting point of Au_2Bi is 373° C. EF (10)

Hardening Phenomena in Aluminum Bronze (Die Härtungserscheinungen in Aluminiumbronze). E. SÖHNCHEN. *Giesserei*, Vol. 22, June 7, 1935, pages 289-294. The properties of the system Cu-Al are reviewed by the constitution diagram. The eutectoid is at 11.9% Al. Transformation points of different compositions were determined; while the character of the curves of electric resistance was very similar, the temperatures at which transformations occur vary considerably with the Al content, between 380° and 480° C. for one, and between 500° and 600° C. for the second transformation. The effect depends also on the velocity of cooling, grain-size, and method of casting. The opposite effect on hardening of grain size in steel and in Al bronze is explained. 13 references. Ha (10)

X-Ray Investigation of Deformation Structures of Metallic Materials (Röntgenuntersuchung von Verformungstexturen metallischer Werkstoffe). FRANZ WEVER. *Kolloid Zeitschrift*, Vol. 69, Dec. 1934, pages 363-368. Paper before the 10th General Meeting of the Kolloid Gesellschaft, Hanover, Sept. 1934, reviews the history and manner of representation of deformation structures, structures of cold-drawn, upset, and cold-rolled metals. Regarding the practical significance of the deformation structure, it is pointed out that elimination of isotropy detrimentally affects many commercial operations, such as deep-drawing. Many metals exhibit the deformation structure even after recrystallization or develop a peculiar recrystallization structure. EF (10)

New Differential Dilatometer (Sur Un Nouveau Dilatomètre Différentiel). OTAKAR QUADRÅT & RUDOLF POSPISIL. *Chimie et Industrie*, Vol. 29, June 1933, pages 623-630. The authors describe a new differential dilatometer with optical registration. By applying Chevenard's principle, they have succeeded in eliminating defects in other apparatus and in obtaining certain improvements. MAB (10)

2 **The Structure of the Intermetallic Compound Au_2Pb.** HARALD PERLITZ. *Acta et Commentationes Universitatis Tartuensis Dorpatensis*, Sect. A, Vol. 27, Aug. 31, 1934, 15 pages. In English. X-ray investigation on 4 Au-Pb alloys covering the concentration range from 84.5 to 50.5 at. % Au confirmed the existence of the intermetallic compound Au_2Pb previously found by Vogel (*Zeitschrift für anorganische Chemie*, Vol. 45, 1905, pages 11-23). Au_2Pb has a very narrow homogeneity range in the vicinity of 66.6 at. % Au, is face-centered cubic, has a lattice parameter of 7.91 A.U. and contains 24 atoms per unit cell. Absent reflections suggest one of the space groups O^7_h, O^4 or T^4_h. An analogy of the dimensions of the atomic radii in Au_2Pb, Cu_2Mg and Bi_2K is pointed out. EF (10)

Apparatus for Thermal Analysis of Metallic Specimens (Appareil pour l'Analyse Thermique des Échantillons Métalliques). JOHN L. HAUGHTON. *Chimie et Industrie*, Vol. 31, Apr. 1934, pages 439-441. The suspended furnace rises and falls, but the specimen remains fixed. The rate of heating or cooling may be regulated within large ranges. The apparatus is operated in vacuum. Thermocouple wires should not be exposed to the maximum heating zone. MAB (10)

4 **The System Iron-Cobalt-Titanium (Das System Eisen-Kobalt-Titan).** W. KÖSTER & W. GELLER. *Archiv für das Eisenhüttenwesen*, Vol. 8, Apr. 1935, pages 471-472. The system Fe-Co-Ti was studied up to 22% Ti. The compound Fe_3Ti forms an unbroken series of solid solutions with the probable compound Co_3Ti. The effect on the eutectic in the Fe-Ti system on the addition of Co and on the peritectic in the Fe-Co system on the addition of Ti are shown. Precipitation hardening alloys were found in the composition regions 55 Co, 7.6% Ti; 9% Co, 4.5% Ti; and 75% Co, 4.5% Ti—remainders Fe. SE (10)

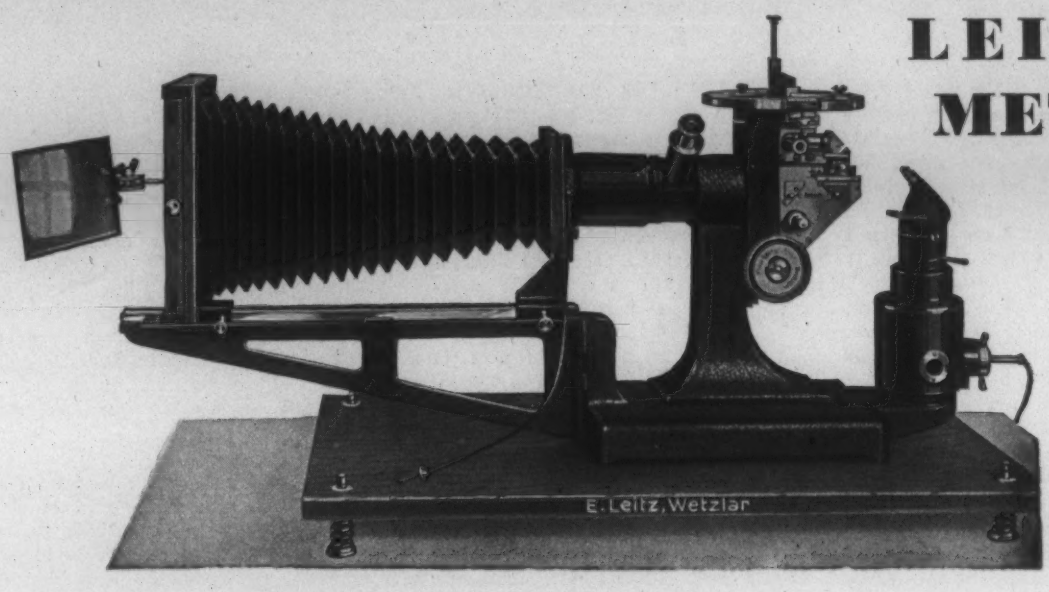
5 **Observations on Topochemistry (Bemerkungen über Topochemie).** H. STÄGER. *Korrosion & Metallschutz*, Vol. 11, Apr. 1935, pages 73-88. Topochemical is the term selected for reactions which cannot go on freely in space, but are restricted to certain positions in the system. Topochemical and kinetic reactions are distinguished, the former occurring at a certain restricted space, while the latter can take place unhindered in space. This conception is applied to corrosion phenomena, porosity, and deformation of structure. Corrosion is a pronouncedly local phenomenon, and corrosion fatigue can be explained by the fact that definite structural changes are developed by the fatigue stresses, particularly in Cr (which shows several structures, depending upon manner of deposition, and which gives, therefore, different degrees of protection). A number of examples of destroyed structures illustrate the application of this hypothesis; it is attempted to show that it will be possible to arrive at a better utilization of materials and to protect structures from destruction. 13 references. Ha (10)

6 **Some Applications of X-Rays (Quelques Applications des Rayons X).** H. BRASSEUR. *Revue Universelle des Mines*, Vol. 11, May 1935, pages 238-239. Special uses of X-rays in the metallurgical and metallographical fields are discussed. Ha (10)

7 **Hardenable Bronzes on a Copper-nickel tin Basis. IV. Influence of Hardening on Corrosion Resistance (Ueber aushärtbare Bronzen auf Kupfer-Nickel-Zinn-Basis. IV. Einfluss der Vergütung auf den Korrosionswiderstand).** E. FETZ. *Korrosion & Metallschutz*, Vol. 11, May 1935, pages 100-107. The corrosion resistance of Cu-rich alloys of the system Cu-Ni-Sn was studied in 3% HNO_3, 3% and 10% HCl, as a function of heat treatment under different test conditions and temperatures. HNO_3 causes, in hardened alloys, a total destruction due to action of local elements which is stronger the greater the amount of the phase which has been precipitated in ultramicroscopic dispersion from the supersaturated, solid α solution. The corrosive action of HCl increases in the presence of an oxidizing agent; 3% HCl forms, on tempered specimens, a compact protective layer, which is not quite so effective in 10% HCl. Annealed Cu-Sn, Cu-Ni, and Cu-Ni-Sn α alloys have approximately the same corrosion resistance in HCl and HNO_3 as the Cu basic alloy. The attack increases with higher Ni content in HNO_3 and decreases in HCl; the average loss in weight was 1:1.9:7.7 in 3% HCl, 10% HCl and 3% HNO_3, respectively. A 7.5 Ni-8 Sn bronze did not show an appreciable deterioration of the mechanical properties after 1 month's corrosion in moving seawater. Practical applications of hardened Ni bronzes are discussed. Ha (10)

8 **Rate of Polymorphic Transformations. II. (Die Geschwindigkeit polymorpher Umwandlungen. II).** ERNST COHEN & A. K. W. A. VAN LIESHOUT. *Zeitschrift für physikalische Chemie*, Ser. A, Vol. 173, Apr. 1935, pages 67-70. The so-called "region of indifference" of polymorphic transformations of some substances, as e.g. Sn, is not a specific property of these substances and can be eliminated by suitable preliminary treatment. Contrary findings of various authors are laid to improper preparation of the specimens. ORS (10)

10 **Physical-chemical Studies on Tin. X. The Transformation Temperature: Gray Tin ⇄ White Tin (Physikalisch-chemische Studien am Zinn. X. Die Umwandlungstemperatur graues Zinn ⇄ weisses Zinn).** ERNST COHEN & A. K. W. A. VAN LIESHOUT. *Zeitschrift für physikalische Chemie*, Abt. A, Vol. 173, Apr. 1935, pages 32-34. The temperature of the polymorphic transformation: gray Sn ⇄ white Sn is 13.2 ± 0.1°C. The measurements were made on specially prepared highly active metal in which this reaction proceeds without the usual sluggishness. ORS (10)



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Investigations of Molecular Solid Solutions in the System Copper-gold (Untersuchungen über molekulare feste Lösungen im System Kupfer-Gold). N. W. AGEEW & D. N. SHOYKET. *Annalen der Physik*, Series 5, Vol. 23, May 1935, pages 90-104. The system has 2 compounds, AuCu and $AuCu_3$, the former has a tetragonal, the latter a cubic face-centered lattice. Alloys of these compounds were investigated. Their structure consists of 2 lattices of which the one is occupied by Au atoms, the other by Cu atoms; the arrangement of the atoms depends on the composition and is shown in curves. Physical properties are tabulated. Ha (10) 6

Determination of the Curvature Axis of Bent Crystals from Laue Photographs (Über die Bestimmung der Krümmungsachse gebogener Kristalle aus Lauediagrammen). W. BOAS & H. EKSTEIN. *Zeitschrift für Kristallographie*, Vol. 90, May 1935, pages 408-414. Based on the assumption that asterism in Laue pictures is due to the bending of the reflection planes of crystals about one axis of curvature, the position of this axis with reference to the incident X-ray beam is calculated from transmission and back-reflection photographs. No indexing of the photographs is necessary. From the photographs, the position of 2 points and the angles between the tangents on the asterism curves and the X-ray beam are taken as a basis for the calculation. The case of a drawn crystal of Zn is worked out as an example. EF (10) 7

Interpretation of Weissenberg Photographs in Relation to Crystal Symmetry. D. CROWFOOT. *Zeitschrift für Kristallographie*, Abt. A, Vol. 90, Mar. 1935, pages 215-236. In English. The determination of the point group symmetry is discussed in relation to Weissenberg reciprocal lattice projection. A method is then given in table form by which the point group symmetry of the crystals may be deduced from equatorial and layer line Weissenberg photographs taken about a single rotation axis. EF (10) 8

Constitution of Mg-Zn-Si Alloys Rich in Mg (Sur la Constitution des Alliages Magnesium-Zinc-Silicium Riches en Magnesium). EMILE ELCHARDUS & PAUL LAFITTE. *Comptes Rendus*, Vol. 200, June 3, 1935, pages 1938-1940. In system Mg-Si, a eutectic appeared at 2.7% Si with a melting point of 575° C. The existence of a ternary eutectic was determined with a melting point of 314° C. and a composition of Mg 51.85%, Zn 47.7% and Si 0.45%. FHC (10) 9

Particle Size Determinations by X-rays and Electron Rays (Über Teilchengrössenbestimmungen mit Rontgenunde- und Elektronenstrahlen). R. BRILL. *Kolloid Zeitschrift*, Vol. 69, Dec. 1934, pages 301-310; discussion, pages 311-312. Paper before the 10th General Meeting of the Kolloid Gesellschaft, Sept. 1934, Hanover attempts (1) to present the fundamentals of both methods in a plausible manner excluding mathematical formulas and (2) to demonstrate the possibilities of those methods which have gained practical significance. One typical example is discussed and illustrated for each application. Among others, a set of 5 films is shown taken on electrolytic Ni of varying grain size. The difficulties in evaluating particle sizes due to their peculiar dimensions are critically discussed. EF (10) 10

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11. PROPERTIES OF METALS AND ALLOYS

Suggestions for Testing and Calculating of Minimum Values of Mechanical Properties in General Specifications for Cast Iron (Kort verslag over proeven ter bepaling van de minimum waarden, welke voor de mechanische eigenschappen in allgemeene voorschriften vor gietijzer kunnen worden aangenomen). D. VAN DEN BERG, W. MAAS GEESTERANUS & E. B. WOLFF. *De Ingenieur*, Vol. 50, Mar. 15, 1935, pages Mk7-Mk8. Suggestions for diameter of test specimens of cast Fe for tensile and bending tests and admissible values of load and deflection for different diameters. Kinds of tests given in Dutch specifications are tabulated. Ha (11)

On the Relation between Fusion and Strength. H. JEFFREYS. *London, Edinburgh & Dublin Philosophical Magazine & Journal of Science*, Vol. 19, Apr. 1935, pages 840-846. Present ideas on elastic failure in a solid as result of local melting are discussed. A solid begins to flow under a stress such that the melting point is lowered to the actual temperature. The effect of stress on the melting point is considered for a substance in the solid and liquid state and a relation established between strength and pressure for a given substance. This can be expressed by log (T_1/T_2) where T_1 is the melting point at the actual pressure and T_2 the actual temperature. This relation is applied to determine pressures and melting points in the earth's crust. Ha (11)

11a. Non-Ferrous

A. J. PHILLIPS, SECTION EDITOR

The Influence of Impurities on the Properties of Lead. Part II. The Effect of Heat Treatment on the Mechanical Properties of Commercial Lead. J. NEILL GREENWOOD. *Proceedings Australasian Institute of Mining & Metallurgy*, No. 95, Sept. 30, 1934, pages 79-124. Using commercial Pb analyzing Bi 0.0023, Fe 0.0007, Sb 0.0040, Cd. 0.0002, Sn nil, Ni trace, Cu 0.0002, Ag 0.0003, Zn 0.0005% and As nil, it was found that (1) under a stress of 1100 lb./in.², the longer the time elapsing between casting and starting the creep tensile test, or between annealing at 125° C. and starting the test, the shorter is the time which the piece will withstand the stress before fracture occurs; (2) the work hardening capacity, under a stress of 1100 lb./in.² of Pb cooled from an elevated temperature, rises to a maximum 1 day after cooling and thereafter decreases for approximately 100 days at 18-20°; (3) under a stress of 500 lb./in.², the longer the time elapsing between the last heating and the starting of the creep tensile test, the smaller is the initial stretch, i.e., the precipitation of impurities from solid solution stiffens the crystal structure; (4) the removal of O_2 from commercial Pb gives a material that under a stress of 500 lb./in.² is softer and recrystallizes with a smaller deformation than ordinary Pb and (5) O_2-free commercial Pb becomes almost identical with air-melted Pb after annealing in air at 130°, suggesting that atmospheric gases can be absorbed in the solid state. Using Pb containing only Cu 0.0001, Fe 0.0001, Zn 0.0001, and Bi 0.0002%, i.e., removal of 0.007% of the impurities plus an unknown amount of O_2 from commercial Pb results in appreciable softening and also removes the great sensitivity to heat treatment. AHE (11a)

New Non-Ferrous Metals. *Journal of Commerce, Shipbuilding & Engineering Edition*, Feb. 14, 1935, page 5. The effect of the additions of Al to Ni-Cu alloys, nickel silvers, nickel brasses, and nickel bronzes is to produce a series of alloys responsive to heat treatment, as a result of precipitation hardening, whereby such alloys, after suitable heat treatment, can be fabricated in their softest condition by cold work, and then hardened by reheating to 400°-650°C. Such treatment gives marked increases in tensile strength, elastic limit and yield point, and a uniform hardness is obtained. JWD (11a)

Use of the Designation "Bronze" is Protected by Law (L'Emploi de la Designation "Bronze" est regi par la Loi). L. J. GOUTTIER. *Revue de Fonderie Moderne*, Vol. 29, Mar. 25, 1935, pages 100-101. According to a new French regulation, the name "bronze" can be applied only if the object contains at least 65% of its weight in Cu. The remainder can be of other metals. Ha (11a)

New Heat-Treatable Alloys Containing Nickel. J. MCNEIL. *Metal Treatment*, Vol. 1, Spring 1935, pages 38-42. By adding Al, Si, or Be to Ni-Cu alloys, age-hardening characteristics are imparted, and it is possible to combine the ductility and corrosion-resistance of the latter with high mechanical strength. An account is given of the properties of a number of these alloys, including the proprietary alloys "K" Monel, and "Kunial" copper and brass. JCC (11a)

The Hall Effect and Some Other Physical Constants of Alloys. IV. The Bismuth-Cadmium Series of Alloys. S. GABE & E. J. EVANS. *London, Edinburgh & Dublin Philosophical Magazine & Journal of Science*, Vol. 19, Apr. 1935, pages 773-787. The equilibrium diagram of the system Bi-Cd is simple and consists of 2 branches meeting at the eutectic which contains 40% by weight of Bi. Crystallization temperature of the eutectic is 140° C. All alloys are heterogeneous mixtures of Bi and Cd in various proportions. Curves for electrical and physical properties were established. 15 references. Ha (11a)

Notes on the Effect of Interrupted Straining on the Elongation of Lead. J. C. CHASTON. *Journal Institute of Metals*, Vol. 57, Apr. 1935, pages 163-172 (Advance Copy No. 698). Commercially pure Pb may exhibit very high values of elongation in the tensile test if the straining is interrupted at intervals and the specimen allowed to age for a few minutes. For an elongation of 2.1 in./in./min. and stretching 13% between aging periods there is a definite increase in the elongation as the aging period increases from 30 sec. to 4 min., but there is a much greater increase in elongation as the time is increased above 4 min. As the rate of stretching at periodic straining increases the total elongation increases. For a given aging time the total elongation rose and then fell as the amount of straining at each loading increased. Pb of relative large grain size and Pb alloys did not show appreciable increase in total elongation with periodic straining. Increased elongation with periodic straining is probably attributable to recrystallization during the aging periods. JLG (11a)

A.S.T.M. Specifications for Copper-Silicon Alloys. *Metal Industry*, London, Vol. 45, Oct. 26, 1934, page 392. On recommendation of Committee B-5, the A.S.T.M. approved for publication tentative specifications covering (1) Cu-Si alloy plates and sheets, (B 96-34T); (2) sheet Cu-Si alloy, (B 97-34T); (3) Cu-Si alloy rods, bars and shapes, (B 98-34T). HBG (11a)

Engineering Properties of "K Monel" Metal. *Metals & Alloys*, Vol. 6, Apr. 1935, pages 101-105; *Inco*, Vol. 12, 1935, pages 8-10. An extended abstract. Describes in detail the properties of Monel to which Al 3-5% has been added. Heat treatment develops spring properties. Non-magnetic characteristics are not destroyed by heat treatment or cold work. 4 grades are described having hardness after aging treatment from softer than 25 to harder than 325 Brinell and tensile strength 120,000-160,000 lb./in.² and good elongation. Alloys are readily machinable and corrosion resistance is equal to Monel. Some applications are described. WLC (11a)

Comparison of Properties of Pure Zinc with Other Zinc (Propriétés d'un Zinc d'une Pureté Exceptionnelle Comparés a celles d'autres Échantillons de Zinc) LOUIS BONCHET. *Comptes Rendus*, Vol. 200, Apr. 29, 1935, pages 1535-1536. Pure Zn prepared by N. J. Zinc Co. by fractional distillations in vacuo had only 0.0001% impurities. Samples of purest commercial Zn used had 99.995% purity. Pure Zn was more resistant than other samples to action of HCl and H_2SO_4. Author believes it possible to determine purity of samples based on rate of solution of metal in appropriate liquids. FHC (11a)

The Theoretical Strength of Materials. WILLIAM H. BRAGG. *Engineering*, Vol. 139, Feb. 15, 1935, pages 178-179.

From a paper entitled "The theoretical strength of materials and their practical weakness," read before the Royal Institution. States that it was only comparatively recently that it had been possible to calculate the strength of materials. VSP (11a)

Aluminum and the Light Alloys (L'aluminium et les alliages légèrs) *Journal du Four Electrique*, Vol. 44, Apr. 1935, pages 131-132. Generalities. JDG (11a)

Bearing Metals Containing Silver. *Engineering*, Vol. 139, Mar. 15, 1935, page 284. Addition of very small amounts of Ag has beneficial effect on mechanical properties of Cu. Latest use of Ag is as a constituent of a certain class of bearing metal. The Federal Mogul Corporation of America has recently developed a Cd-Ag-Cu bearing alloy, C. S. 50; it melts at about 330° C. when particles of solid solution of Ag in Cd separate from the melt. On further cooling more of solid is formed until about 314° C. the Cd-Cu eutectic forms in grain boundaries and alloy becomes wholly solid. Claims for alloy include higher factor of safety at elevated temperatures and higher physical properties than for Sn-base alloys at all operating temperatures. Increasing attention is being given to Cd-base bearing alloys. Ag and Cu have a hardening effect on Cd and also confer other useful properties from bearing-metal point of view. VSP (11a)

11b. Ferrous

V. V. KENDALL, SECTION EDITOR

Brittleness in Steel. CARL L. SHAPIRO. *Iron Age*, Vol. 135, Feb. 21, 1935, pages 12-17; Feb. 28, 1935, pages 26-29, 73-75; Mar. 14, 1935, pages 21-25, 76. Gives methods of testing steel brittleness used at Harvard University and correlates results of many tests on blue brittleness, transformation shortness, and secondary and carbide brittleness. Also defines and describes the pseudo blue heat range of stainless 18-8 steels. Steels tested in the investigation ranged from Armco Fe (0.02%C) to steels analyzing 1.58%C. Other metals tested were wrought Fe, cast steel, alloy steel and nitrided steel. Each type of steel was tested in annealed, air cooled, quenched sorbitized and spheroidized conditions at various temperatures and compared to the others. Brittleness of steels in various heat treated conditions were tested by the determination of strength and ductility. All torsional results secured by these tests are given in a series of 3-dimension diagrams. Strength of normalized hypo-eutectoid and hyper-eutectoid steels increases with C content. Maximum breaking weight is at 300° C. in all types of normalized carbon steels. Ductility decreases with C content and indicates that blue heat range is at 300°C. in hypo and eutectoid steels and little lower in hyper-eutectoid steels. Secondary brittleness is recorded in hyper and eutectoid steels, but not in lower C steel. Low C 18-8 steel with 0.06% C and high C steel with 0.15% C were tested in annealed austenitic condition. Low C steel at room temperature was very strong and at first resisted deformation, but gradually yielded with increased load and it finally steps before failure. High C 18-8 Cr-Ni steel showed a marked tendency to step just before failure in room temperature test. Heating at 650° C. does not blue stainless 18-8 steels, but causes it to exhibit all other characteristics of blue heat range. Swedish wrought Fe weight increases steadily until its maximum at 250° C. and then decreases slowly. Angle of twist diminishes from room temperature to 200° C. and then rapidly increases. Blue brittleness was observed at 300° C. and secondary brittleness at 600° C. Results of tests are tabulated and includes many diagrams. Gives a number of foot-note references. VSP (11b)

Bond between Reinforcing Steel and Brick Masonry. E. F. GALLAGHER. *Brick & Clay Record*, Vol. 86, Mar. 1935, pages 92-93. As a result of tests, specially shaped bricks around steel are recommended to permit greater areas of mortar. This increases the bonding power and thus the strength of the whole structure. Ha (11b)

The Prevention of Weld Decay. E. C. ROLLASON. *Metallurgia*, Vol. 11, Apr. 1935, pages 159-161. Brief discussion of methods that have been used to prevent weld decay in steels of the 18-8 type. JLG (11b)

Production, Properties, Analyses and Uses of Cobalt Magnet Steels. EDWIN F. CONE. *Steel*, Vol. 96, May 13, 1935, pages 48, 50. Deals with these steels as produced by the Bethlehem Steel Co. High-Co permanent magnet steel contains 0.90% C, 0.40% Mn, 5% Cr, 4% W, and 38% Co. It has a residual induction of 9,500, coercive force of 235, and energy product of 900,000 when quenched in oil from 1740° F. Steel is melted in high-frequency induction furnaces and poured into 4½-in. sq. ingots. Small size aids in eliminating most of the carbides. Size of carbide particles varies with size of rolled product. Ingots are hammer cogged to billets, which are ground, pickled, and rolled hot into bar stock. Hardness after rolling is 50 Rockwell C or 534 Brinell. Rubber bonded wheel is used for cutting bars. Straightening is prohibited. In general, no heat treatment is employed. For hardening, steel is quenched in oil from 1740°-1750° F. When necessary, special anneal lowers hardness about 100 points. Generally, steel is not "touched" after hot rolling. In hot working, it must be heated in as short a time as possible. Important uses are in aëroplane equipment, magnetos, phonograph pick-ups, and scientific instruments. Castings can now be produced successfully. Tabulates composition and properties of other magnet steels produced by the company. MS (11b)

Investigations of a Rail Steel with Regard to Hardening by Additions of Copper (Untersuchungen an einem Schienenstahl über die Aushärtung bei Zusatz von Kupfer). E. G. LUEG. *Mitteilungen aus den Forschungsanstalten des GHH-Konzerns*, Vol. 3, Apr. 1935, pages 199-205. An investigation was conducted to determine whether the increased corrosion resistance of Cu steels could be used for rails where great hardness and wear resistance are required. A steel with 1.1% Cu, 0.62% C, 0.72% Mn, 0.032% P, 0.029% S and 0.25% Si was heat-treated in a salt-bath at different temperatures for various lengths of time. Brinell hardness showed a maximum increase after 36 hrs. at 450° C. The greatest difference between the original and the hardened state, calculated from the Brinell hardness, amounted to about 16 kg./mm.² Examination of the wear resistance made on a Spindel machine revealed that the specimens of greatest hardness showed the worst wearing properties; wear resistance decreases with increasing Brinell hardness. Notch-toughness also varies inversely with Brinell hardness. Metallographic examination showed that the hardening is not recognizable in the etched section. Annealing with very slow cooling showed, under high magnification, great quantities of dissolved Cu as a fine segregate. 5 references. Ha (11b)

Magnetic Behavior of Cold Rolled Iron-Nickel Alloys (Development of Isoperms) (Magnetisches Sonderverhalten kaltgewalzter Eisen-Nickel-Legierungen (Entwicklung der Isoperme)). O. DAHL & J. PFAFFENBERGER. *Metallwirtschaft*, Vol. 14, Jan. 11, 1935, pages 25-28. The alloy 40% Ni, 60% Fe, without addition of a third metal, was found to have very desirable magnetic properties, low hysteresis and high susceptibility, if properly treated. The best treatment consisted of a very high reduction by rolling, over 90%, before the last anneal, annealing at 1000° C. and further reduction of 60%. This treatment results in the formation of a distinct fiber structure, which is necessary for isoperm properties. 10 references. CEM (11b)

Thermoperm, a Material with Magnetization Variable with Temperature (Thermoperm, ein Werkstoff mit temperatur-verändlicher Magnetisierbarkeit). F. STÄBLEIN. *Technische Mitteilungen Krupp*, No. 5, Dec. 1934, pages 127-128. This material is valuable in correcting the temperature error of electrical measuring instruments. It has a low Curie point like a 30% Ni alloy of Fe. Composition is not given. The Curie point is dependent on field strength. Calculations for a typical application are given and it is recommended that the alloy be used saturated, so that compensation effect is proportional to area of cross section. MG (11b)

Manganese Steel Casting with Higher Strength (Manganstahlguss mit höheren Festigkeitseigenschaften). V. ZSAK. *Giesserei*, Vol. 22, Apr. 26, 1935, page 195. A steel of 0.23% C, 1.38% Mn, 0.54% Si, 0.046% P showed mechanical properties, hardened and not hardened which were in every respect equal to alloy steels. The ratio of elastic limit to ultimate strength of the hardened specimens was over 60%, reduction of area about 35%, the notch-toughness 9.1 and 12.5 kg./cm.² for quenching in oil at 600° C. from 800° and 850° C. respectively. The steel was made in an acid electric furnace. Ha (11b)

Grain Size Control and its Effect on the Mechanical Properties of Forgings. J. M. ROBERTSON. *Metal Treatment*, Vol. 1, Spring 1935, pages 21-29. Differences in the "body" or quality of steels having the same composition are related to the ease with which large grains of austenite are developed on heating. This in turn can be controlled by the deoxidation treatment. Additions of Al, when the oxide content of the bath is suitable, produce submicroscopic refractory particles which act as nuclei during solidification and obstruct crystal growth during heat treatment. Methods of determining austenitic grain size are described. Coarse grained steels harden more deeply, are less liable to soft-spots, machine more easily, and react as "normal" in the McQuaid-Ehn test. Fine grained steels have higher impact strength, greater toughness, and less distortion after hardening or carburizing. They react abnormally in the McQuaid-Ehn test, but can be successfully carburized without grain growth by using higher temperatures and can often be quenched from the box. 19 references. JCC (11b)

Malleable Iron—Its Properties and Applications. D. P. FORBES. *Iron Age*, Vol. 135, Apr. 4, 1935, pages 43-45; *Foundry*, Vol. 63, May 1935, pages 23, 63. From a paper presented at joint meeting of Western Society of Engineers, Chicago section of American Foundrymen's Association and Chicago section of American Society of Mechanical Engineers, Mar. 18, 1935. Usual commercial malleable Fe has a carbon content slightly under 2.50% and Si slightly under 1.00% with other impurities such as Mn, S and P within certain definite limitations. Heat treatment consists of holding castings at 1600° F. or more to break down Fe_3C into temper C nodules and solid solution of Fe_3C in Fe. The metal has tensile strength ranging from 50,000 lbs./in.² for high-C Fe to 60,000 lbs./in² for low-C Fe. Malleable Fe is unusual in that yield point is a very high % of ultimate strength. High yield point means good ductility. Malleable Fe can be machined at higher rate of speed than any other ferrous metal, with possible exception of fully annealed cast Fe. Its applications are in automotive vehicles, railroad and agricultural fields. Some of the miscellaneous applications are: lawn mower gears, washing machine parts, pipe fittings, hardware items, etc. Improvement in elimination of shrinks and primary graphite in last 10 years has increased the market for malleable Fe. VSP (11b)

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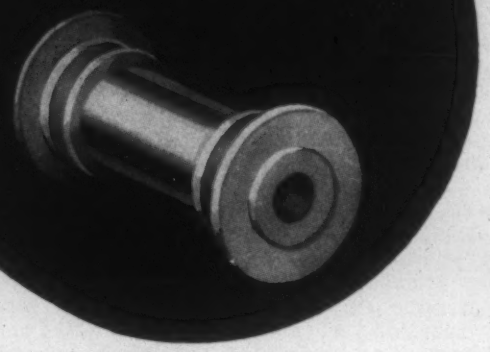

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12. EFFECT OF TEMPERATURE ON METALS AND ALLOYS

L. JORDAN, SECTION EDITOR

The abstracts in this section are prepared in co-operation with the Joint High Temperature Committee of the A.S.M.E. and the A.S.T.M.

Creep Strength of Metals and Their Utilization by the Designer (Die Dauerstandfestigkeit metallischer Werkstoffe und ihre Anwendung durch den Konstrukteur). D. W. RUDORFF. *Zeitschrift Verein deutscher Ingenieure*, Vol. 79, Apr. 13, 1935, pages 453-458. Recent investigations and results are reviewed; the difficulties of evaluating results for practical purposes is pointed out and a few examples illustrate how values of creep strength can be used by the designer. Ha (12)

On the Sensitivity of Alloyed Steels to Oxidation Phenomena (Über die Empfindlichkeit legierter Stähle gegen Verbrennungserscheinungen). H. SCHRADER. *Technische Mitteilungen Krupp*, Vol. 2, Dec. 1934, pages 136-142. The influence of alloying elements on oxidation phenomena emphasizes the importance of careful consideration of heating conditions in choosing a suitable alloy steel. Some alloy steels show a diffusion of the oxide into the surface layers subsequent to the exposure which produces the oxidation. Specially effective against oxidation are Ni, Co, and Mo steels, while additions of Cu, Si, Al, Cr, and W produce an improvement when compared with C steels. In C steels neither the C content nor the steel making process has much effect on oxidation phenomena. Mn, V, and Ti also have little effect. MG (12)

On the Oxidation of Iron and Steel at Elevated Temperature and the Structure of the Scale. KATSUJIRO ENDO. *Reports of Research Laboratory Nippon-Seitetsu-Yawata-Steel-Works (Japan)*, Vol. 14, Jan. 30, 1935, pages 1-16. In Japanese. Utilizing the thermo-balance, the increase of weight due to oxidation of 6 C-steels (0.11-0.62%C) heated at various temperatures from 800°-1200°C. for 20-60 mins. was measured. Weight increase-time curves were obtained. The curves obtained from mild steel are given by the formula, $W^x = K \cdot t$, (theoretically derived from Fick's law) where W and t are degree of oxidation and time resp. and K and x are functions of temperature. Curves for higher C-steels are given by the formula $W = Dy^h$, where D and h are functions of temperature and y is distance from the surface of specimen. According to the microscopic and X-ray analyses, the oxide layer consists of 3 parts. The outermost part consists of Fe_2O_3, the middle portion of Fe_3O_4 and the inner portion of a mixture of Fe_3O_4 and FeO. The mechanism of oxidation is discussed. TS (12)

An Effect of Oxygen and Sulphur on Iron in Scaling. J. H. WHITELEY. *Iron & Steel Institute*, May 1935, Advance Copy No. 10, 19 pages. A network structure that forms at the boundaries of either α or γ surface grains when steel is scaled is described. It is revealed by the usual etching reagents, including cupric reagents, and its intensity depends on the temperature and time of heating. The structure does not penetrate deeply and is primarily due to the presence of O exceeding the amount soluble in the Fe grains. When steel is welded by wash heating the structure is usually to be found at the weld. It disappears, apparently by diffusion, when heated in the absence of O at higher temperatures in both the α and γ ranges. In purer materials, such as electrolytic Fe, the structure is either weak or fails to appear. S causes intensification of the structure but other elements along with S may influence the formation of the structure. The action of S on scale intrusion into austenite grains is discussed. It is suggested that the network structure and the ferrite bands in banded steel are due to the same cause, namely, a non-uniform distribution of O and S. 9 references. JLG (12)

Modulus of Elasticity of Metals at Different Temperatures (Le Module d'Élasticité des Métaux à Différentes Températures). A. MITINSKY. *Chimie et Industrie*, Vol. 29, June 1933, pages 616-619. A simplified apparatus to test flexibility is placed in a furnace. The specimen lies free on 2 supports and the load is applied at its center. A micrometer measures the displacement at the free end of the specimen as it leaves the furnace. The modulus of elasticity of different brasses and steels is measured at temperatures up to 800°. MAB (12)

Modern Materials for High-Pressure Vessels. L. P. MCALLISTER. *Welding Engineer*, Vol. 20, May 1935, pages 30-32; *Iron Age*, Vol. 135, June 6, 1935, pages 24-26, 108, 110, 112. Alloy steels and clad steels for shells and heads of welded pressure vessels to give high strength at elevated temperature, high impact resistance and improved creep values are discussed. Examples of large vessels are described. Ha+VSP (12)

Heat Resistant Nickel-Chromium-Iron Alloys (Über wärmefeste Nickel-Chrom-Eisen Legierungen). *Die Metallbörse*, Vol. 24, Dec. 1, 1934, pages 1529-1531; Dec. 8, 1934, pages 1561-1562. The Cr-Ni-Fe alloys discussed include only alloys with less than 50% Fe. The addition of Fe to Cr-Ni alloys is not only intended to reduce the price but also brittleness. Some 60 trade names and chemical compositions of Cr-Ni-Fe alloys with or without further additions of Mn, Si, W, Mo and C are collected. 5 tables show the physical properties of Cr-Ni-Fe alloys at room and elevated temperatures. The effect of C and Si is discussed at length. Raising the Si content from 0.3% to 2.0% improved the scaling resistance from 5.3 mg./cm². to 0.3 mg./cm². (weight increase due to oxidation). EF (12)

Relation of Temperature to Indentation Hardness of Metals. I. (Die Temperaturabhängigkeit der Kegeldruckhärte der Metalle. I). J. ENGL & G. HEIDTKAMP. *Zeitschrift für Physik*, Vol. 95, May 14, 1935, pages 30-41. Description of apparatus for measuring, with a conical penetrator, the indentation hardness of metals heated as high as 1900° C. Curves are plotted to show the decrease of hardness, with increasing temperature up to the melting point, of electrolytic Cu and of 3 samples of single crystals of pure Cu taken parallel to the 001, 011 and 111 planes. FHC (12)

13. CORROSION AND WEAR

V. V. KENDALL, SECTION EDITOR

Factors Influencing the Nitric Acid Test for Stainless Steels. JOHN L. MILLER. *Journal American Society Naval Engineers*, Vol. 47, May 1935, pages 241-246. Discussion of the W. R. Huey test with 66-67% HNO_3. Determined the effect of amount of acid used between 300-800 cc., effect of initial acid concentration in range of 60-71% HNO_3, effect of previous exposure of acid to air, effect of using the same acid for more than one period which actually is determining the effect of impurities in the acid from previous corrosion period, effect of using acids from different manufacturers, effect of using acid of different lots from the same manufacturer. Samples from two heats of 20 Cr, 10 Ni steel were used in tests with 3, 4, 5, 6, 7, 8, hundred cc. of C.P. HNO_3 of 1.42 sp.gr. Results show a progressive decrease in total rate of corrosion up to 700 cc., based on 3 periods of 48 hrs. The Navy specification calls for the use of 500 cc. of acid and results show about 25% greater corrosion rate with 500 than with 700 cc. Tests made with 71, 67 and 60% HNO_3 showed the higher concentration to be the most corrosive and the conclusion is that in the "Huey test" the condensation of the acid is effective in preventing change in concentration. Previous exposure of the acid to air was found to have no effect on reproductibility of results. Using the same acid for 3 periods was found to give a corrosion rate more than 12 times greater than in the standard test where the acid is renewed for each period. It was also shown that the greater the sample area exposed the higher the corrosion value obtained for the particular sample thus indicating the desirability of a standard area for the test. The use of acid from different manufacturers gives non-reproducible results from one brand of HNO_3 to the other to the extent of a variation of 45% or more on samples from the same heat. Different lots of acid from the same manufacturer gave max. variation in corrosion rate of 25% for 4 lots of acid tested. A proposal is made that a standard relation of sample area to volume of acid be set up in order to secure comparable results. The suggested standard is 1.5 in.² of exposed area to each 100 cc. of concentrated acid. Other proposals are that the initial acid concentration should be 67% HNO_3 or over, that the acid be changed for each period. The author suggests that where a rigid weight loss specification must be met and values greater than the allowable max. are obtained the use of acid from a different manufacturer or a different lot from the same manufacturer may allow the material to pass the specification. WB (13)

Some Factors Affecting the Corrosion of Telephone Sheaths. CLYDE JAMES GRIFFITHS. *Journal & Transactions Institution of Engineers of Australia*, Vol. 7, Apr. 1935, pages 113-133. A review is made of the various types of corrosion to which Pb telephone cable sheaths are subjected and an outline of the preventive and remedial methods is given with particular regard to conditions in Victoria. A detailed account is given on the investigation of current distribution over extensive sections of the Victorian cable system and on the remedial measures applied to the traction system as well as to the cable system. The latter includes (1) Zn plates, (2) insulating joints, (3) laying of cables in galvanized piping, (4) changing routing of cables and connecting of adjacent stub end cables. With Zn electro-negative to Pb to an extent of 0.64 volts a lowering of the potential of the Pb sheath relative to the surrounding soil is obtained and an appreciable part of the current discharge transferred to the Zn plate. Chemical corrosion was found most likely to occur in the following locations: (a) dark colored soils containing decayed vegetable matter, (b) soil impregnated with common salt, (c) mineralized spring or bore water areas, (d) in contact with concrete and cement. Improperly cured cement gives an alkaline reaction due to free lime. The resulting corrosion product is a characteristic orange-red coating of litharge and red Pb. German, British and American investigations on the corrosion of Pb cables are critically discussed. In parts of Victoria, damage is experienced from white ants due to the deposition of formic acid by the ants in their passage along the cable sheath which exhibits narrow bands of corrosion. Some sheaths show a combination of this and direct mechanical attack. A free application of a 50% mixture of creosote and kerosene or only arsenic powder scared the white ants away. The nature and extent of damage in Victoria arising from inter-crystalline fracture of Pb sheathing is fully dealt with. An analysis of mechanical damages is made. Concludes with miscellaneous aspects of the corrosion problem and a forecast of future developments. WH (13)

Cathodic Protection on Pipe Lines by Wind Driven Generator Unit. NEIL WILLIAMS. *Oil & Gas Journal*, Vol. 33, May 16, 1935, page 29. A description of a wind driven generator unit, operating on a wind velocity as low as 2 miles per hour and used for furnishing current for cathodic protection of pipe lines. Sufficient power is generated to provide full cathodic protection for a distance of 5 miles. VVK (13)

Unsolved Problems Concerning the Use of Aluminum for Overhead Transmission Lines (Offene Fragen bei der Verwendung von Aluminium im Freileitungsbau). CALLIES. *Elektrizitätswirtschaft*, Vol. 24, Nov. 25, 1934, pages 497-499. Paper before the Reichsverband für Elektrizitäts-Versorgung, Oct. 1934, discusses critically the problem of corrosion stability, endurance strength and proper joining devices of Al high-tension cables. States that corrosion attacks were noticed to be due to Cu spangle attached to the Aldrey (duralumin) cables during working. A grease coating on Al is not advisable. An approved method of cleaning Al cables shortly before suspension is still lacking. Chemicals cannot be removed thoroughly and will cause corrosion. The scrap value of Al cables is practically nil contrary to Cu cables. WH (13)

Vulcanized Rubber Is Applied to Pipe Line to Combat Corroson. L. E. BREDBERG. *Oil & Gas Journal*, Vol. 33, Feb. 7, 1935, page 14. The Lone Star Gas Co. has installed a 100 ft. test of 10" pipe line coated with vulcanized rubber. The ¼" rubber coating, vulcanized by a special process is expected to be particularly resistant to soil stress and electrolysis. A "hot spot" in the soil where previous pipe had corroded through in 4 years time was chosen. The test will be inspected next year. VVK (13)

Wear Resistance of Cast Iron (Zur Frage der Verschleissfestigkeit des Gusseisens). K. SIPP. *Automobiltechnische Zeitschrift*, Vol. 38, June 10, 1935, pages 280-286. The question what is wear and to what influences is it due is treated exhaustively on the basis of experiments and publications of other authors on the subject. Causes of wear lie in the structure of the Fe itself, in the composition, and external to the cast Fe. A pearlitic structure doubtless promotes wear, as does ferrite; graphite retards wear, also phosphide, while cementite structure promotes wear. The action of martensitic and nitrided structures is not yet clear. Si promotes graphite formation and therefore, indirectly acts favorably. Mn in the form Mn-S is of no importance for wear, the free Mn increases wear resistance slightly as it promotes a finer grain. P and S are considered as retarding wear but their action, and that of Ni, is not yet determined. Cr undoubtedly retards wear. The influences external to cast Fe consist in the combination of metals, e.g. cast Fe on cast Fe, cast Fe on steel, on bronze. The conditions are not quite elucidated; also the influence of lubrication is not quite clear. The surface condition is of extreme importance. Further research to clear up the many still outstanding questions is advocated. 15 references. Ha (13)

Corrosion of Steel, Quantitative Effect of Dissolved Oxygen and Carbon Dioxide. THOMAS J. FINNEGAN, RICHARD C. COREY & DAVID D. JACOBUS. *Industrial & Engineering Chemistry*, Vol. 27, July 1935, pages 774-780. 25 references. The corrosion of steel in dilute solutions of O_2 and CO_2 was observed. Definite concentrations of these gases were maintained over a period of 21 days in an apparatus in which water continually flowed over the specimens. The prevailing concentrations of the dissolved gases were checked by regular periodic analyses. In these experiments the water temperature was 60° C. and the velocity of flow was 2.5 cm./min. During the progress of an experiment the water became saturated with $Fe(OH)_3$. The corrosion rate was found to be a function of the CO_2 and O_2 concentrations. This relation is shown in a series of curves. One p.p.m. of dissolved O_2 is approx. as corrosive as 20 p.p.m. of dissolved CO_2, and at zero concentration of either gas the corrosion rate is not zero but a value dependent upon the concentration of the other gas. MEH (13)

Cavitation in Turbines and Centrifugal Pumps. ALAN BURN. *Commonwealth Engineer*, Vol. 22, Mar. 1, 1935, pages 253-256. Paper before the Australian & New Zealand Association for Advancement of Science states that if the conditions of flow in any hydraulic machine are such that the absolute pressure at some point falls to the vapor pressure of the liquid, cavitation will set in. With slight cavitation, corrosion is the most serious effect produced. It does not occur where the bubbles are formed, but further on in the region of higher pressure where the bubbles collapse again against a solid boundary and deal out a sort of hammer blow of hundreds of atmospheres. Chemical action alone (O_2, CO_2) is insufficient to explain the extraordinary pitting effects although stainless steel parts exhibited reduced cavitation defects. Stainless steel has been successfully used in building up pitted areas in cast steel runners. Suggests that a thin coating of rubber might prove successful in resisting cavitation corrosion. WH (13)

Corrosion of Type Metal Due to the Effect of Beech Wood (Über Korrosion von Letternmetall unter Einwirkung von Buchenholz). BRUNO SCHULZE. *Zeitschrift für Deutschlands Buchdrucker & verwandte Gewerbe*, Vol. 46, Dec. 4, 1934, pages 880-881. Type metal samples were stored in old and newly made boxes of beech wood. In the latter boxes considerable corrosion of the alloys took place. This is ascribed to the effect of volatile acids (acetic acid) in the presence of higher atmospheric moisture contents. EF (13)

The Economics of Cathodic Pipe Production. W. R. SCHNEIDER. *Gas Age Record*, Vol. 73, Jan. 6, 1934, pages 11-13. Paper presented at Organization Conference of Pacific Coast Gas Association, San Francisco, Nov. 1933. Data are given on the cost of cathodic pipe protection. VVK (13)

Problem of Corrosion of Tar Vessels (Das Problem der Korrosion von Teerblasen). H. SCHILDWÄCHTER. *Brennstoff Chemie*, Vol. 16, Jan. 15, 1935, pages 29-30; *Journal Society of Chemical Industry*, Vol. 53, 1934, pages 847-851, 864-868, 907-912. Reports on corrosion of tar products on 3% Si and 2% Si-Mn steel. Effect of NH_3, effect of temperature, artificial addition of Fe-oxide to the tar and investigation of a great number of metals and alloys in regard to special corrosion conditions set up by tar are discussed. Cr-Ni steels turned out best. EF (13)

Centrifugal Babbitting. *Automobile Engineer*, Vol. 25, May 1935, page 168. A machine for centrifugal babbitting on a commercial basis for lining up to 220 bushings/hr. and up to 8½" diameter is described. The machine requires a 2 h.p. motor. Ha (13)

Wide Variations in Cylinder Finishes Revealed in Different Makes of Cars by the Profilograph. E. J. ABBOTT. *Automotive Industries*, Vol. 72, Mar. 30, 1935, pages 444-448. Investigation of the smoothness of finished automobile cylinders produced by 9 different manufacturers showed the smoothest in a car in the low price range which was given one of the roughest semi-finish hones. Profilographs of cylinders after 20,000 to 40,000 miles service show that all cylinder surfaces do not wear to a mirror-like finish, nor do they roughen to the same extent. Original finish is an important factor in subsequent operation. Worn cylinders showed 4 types of irregularities: small irregularities all over the surface, pits, scratches parallel to the cylinder axis and waviness or undulations on which close spaced roughness is superimposed. BWG (13)

Corrosion from Zero Softened Waters. RAY L. DERBY. *Journal American Water Works Association*, Vol. 27, May 1935, pages 627-630. The zeolite softened water of zero hardness is corrosive due to increased mineralization providing a better electrolyte for corrosion by electrolysis. The pH of zero softened water is usually on the alkaline side and is dangerous to use with galvanized pipes; in one case where lime softening was used to replace zeolite softening the galvanized pipes lasted appreciably longer. Author suggests corrosion by this water can be reduced by the use of uniform metallic piping to minimize dissimilar contacts. Coating the pipe with a thin protective film of $CaCO_3$ or using a water containing 20-35 p.p.m. of $CaCO_3$ are considered best preventives. In case of severe incrustation of the pipe the use of zero softened water is recommended for sufficient duration to decrease the thickness of the crust. WB (13)

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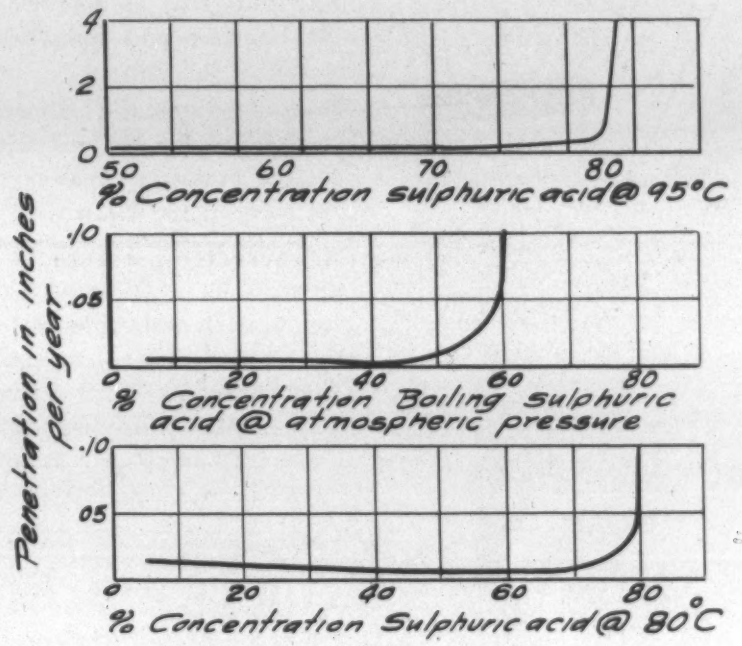

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Ammonia Liquors	**Hydrofluosilicic Acid**
Calcium Hypochlorite	**Oxalic Acid**
Cyanides	**Sodium Hydroxide**
Ferrous Chloride	**Sodium Sulphite**
Ferrous Sulphate	**Tannic Acid**
Hydrobromic Acid	**Zinc Sulphate**

Applications

In Chemical Manufacturing: Miscellaneous equipment for production and handling of various acids.

In Steel Pickling: Bars, tie rods, bolts, nuts, washers, pickling crates and baskets where reducing agents are added to the pickling bath.

In Paper Making: For equipment subject to alum and bleach corrosion.

In Petroleum Refining: Alcumite is suitable for practically all corrosion conditions and especially for acid sludge service.

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Corrosion of Metals in the Oil Industry (Korrosion der Metalle in der Mineralölindustrie). R. Fussteig. *Werkstoffe und Korrosion*, Vol. 10, Mar. 25, 1935, pages 13-15. Due to the presence of salt water of strong acidity or alkalinity in oil wells, metals used in wells and tools are particularly attacked and subject to corrosion because of electrolytic action. The conditions are discussed fully and resistance of various materials tabulated according to American investigations. Al, calorized Fe, steel and stainless steel, especially alloys with 16-18% Cr, are most resistant in cracking apparatus. Ha (13)

Studies of the Attack on Piling Bar in River and Sea Water (Untersuchungen über den Angriff von Spundwandeisen in Fluss-und Seewasser). C. Holthaus. *Archiv für das Eisenhüttenwesen*, Vol. 8, Mar. 1935, pages 379-389. Iron piling, in sea, brackish, and river water for about 20 years was studied to determine the relative corrodibility and life expectancy. The smallest loss in cross-section occurred in the part of the wall subjected only to the atmosphere; the loss was greater in the zone between air and water, and was most just below the water line; deeper down the loss was again smaller. The examination indicated that a life of between 80 and 120 years could be predicted for the piling. In studies of an iron dike in a bay erosion by sand and waves was found to outweigh corrosion. Suggestions for the design of piling sections for such dikes are given. Various soft steels tested in the laboratory under such conditions showed a maximum difference of only about 20% in the wear. SE (13)

Corrosion Phenomena Due to Combustion Gases from Coal Gas (Korrosionserscheinungen durch die Verbrennungsabgase von Steinkohlengas). H. Brückner. *Brennstoff Chemie*, Vol. 16, Feb. 1, 1935, page 54. Critical remarks on the 34th Joint Research Committee Report of the Institution of Gas Engineers and Leeds University. In the case of pitting, corrosion testing by weight loss determination is of little use and should be replaced by the ratio of strength loss % : weight loss %. With uniform surface attack the resulting coefficient = 1 but increases up to 8.6 when local corrosion takes place. While pitting can be detected microscopically, intermetallic corrosion must be determined by physical testing methods. The effect of moisture on corrosion by waste gases is pointed out, a critical relative humidity content being established between 60 and 70% EF (13)

Dielectric Breakdown in Cables. Part 2. E. A. Beavis. *World Power*, Vol. 23, May 1935, pages 233-236. Faults in Pb sheathing and failures due to fatigue, corrosion-fatigue and electrolysis. The various Pb alloys are tabulated as to composition, elongation and fatigue limits. The .5 Sb, .25 Cd sheath is considered most resistant to fatigue failure. WB (13)

Protection from Brine Drippings. John L. Vogel, E. C. Neville & P. G. Lang. *Railway Engineering & Maintenance*, Vol. 19, Apr. 1935, pages 234-235. Steel rails and track fastenings have been protected against brine drippings by the application of hot oil having a high percentage of asphaltic content. However, continuous applications are necessary. Asphaltic oil carrying 55% asphalt can be sprayed and is cheaper than paint. Emulsified asphalt treated with asbestos and troweled onto the steel surface resists brine drippings and shows no cracking. Pure asphalt coatings tend to crack as a result of temperature changes and evaporation of the volatile oil. The use of Cu-bearing steels or wrought Fe plates as a covering is urged. WH (13)

14. APPLICATION OF METALS AND ALLOYS

Popular Base Metals Encountered in the Finishing Shop. *Synthetic & Applied Finishes*, Vol. 6, Jan. 1935, pages 240-242; Feb. 1935, pages 271-274; Mar. 1935, pages 298-302. Discusses softening of mild steel, routine testing of sheet metals (Erichsen cupping test), structural steel, Welsh plate, furniture steel, bright mild steel, mild steel rods, medium C steel, miscellaneous steels (spring, magnet), sheet brass, brass rod, bronzes, Ni-silvers, Al and Al alloys, Zn base die castings. 17 tables compile analyses and the most important physical properties of the above metallic materials which are fully considered under the special conditions prevailing in the finishing industry. EF (14)

14a. Non-Ferrous

G. L. CRAIG, SECTION EDITOR

Improvements in Surface Condenser Tubes. A. Spittle. *Shipbuilding & Shipping Record*, Vol. 45, Feb. 14, 1935, page 180. A survey of the various alloys introduced within the last 10 years to resist corrosion includes 90/10, 85/15, 80/20, 70/30 Cu-Ni alloys, Al brass, and Al bronze. The properties of these alloys are considered and also the progress which has been made on the production side in their manufacture. JWD (14a)

Studies on Aluminum and Aluminum-Magnesium Light (Studien über das Aluminium- und Aluminium-Magnesiumlicht). J. A. M. van Liempt & J. A. de Vriend. *Recueil des Travaux Chimiques des Pays-Bas*, Vol. 54, Feb. 15, 1935, pages 239-244. Pursuing previous research work (See *Metals & Alloys*, Vol. 6, Jan. 1935, page MA 40 R 5 & R 6) the following facts are brought out: the combustion velocity of Al in O_2 is materially lower than that of Mg. The color of the Al light is very similar to that of Mg. The light yield of the Al light = 26 lm./W. Addition of Mg to Al increases its combustibility and reduces its explosion time. The quantity of light/unit of weight developed by Al alloys containing 5-10% Mg is 10-20% larger than with the individual metals. The spectrum of this magnalium light is very similar to that of its components. Further experiments refer to magnalium wires provided with explosive pastes. EF (14a)

Some Experiments with Pure-Metal Resistance Standards. James L. Thomas. *Bureau of Standards Journal of Research*, Vol. 12, Mar. 1934, pages 313-321. National standardizing laboratories use wire-wound standards for maintaining the unit of electrical resistance. The material for these standards is usually manganin, an alloy of Cu, Ni, and Mn. This alloy corrodes rather readily and in general its resistance does not remain as constant as is desired. It is believed that coils of pure metals, especially the noble metals might be more suitable and more stable. Pure metal standards have been therefore constructed and tested of Cu, Ag, Sn, Au, and Pt wire at the ice point. WAT (14a)

Hygienic Value of Aluminum with Respect to Aluminum Household Utensils (Zur gesundheitlichem Beurteilung des Aluminiums im Aluminium-, Ess-, Trink- und -Kochgeschirr). Joseph Würer. *Forschungen & Fortschritte*, Vol. 10, Sept. 20, 1934, pages 335-336; *Archiv für Hygiene*, Vol. 112, 1934, page 198. Recent tests at the Reichsgesundheitsamt Berlin corroborated previous results that the daily use of Al cooking utensils does not introduce unduly large quantities of Al into the food. Dogs were fed with food containing Al salts (mainly Al_2O_3 and $AlCl_3$) for 8-15 months. The organs contained the same amounts of Al as those of a reference dog. Human beings, who ate from 0.5-1 g. Al_2O_3/day for 70 days did not suffer any harm. There was no increase of Al secretion in the urine and practically all of the Al is rejected by the human body. The physiological effect of Al on the latter is discussed from a medical viewpoint and tests on the diffusion of Al salts through diaphragms are reported. Excessive quantities of Al salts only temporarily impaired the appetite of dogs. Al compounds display a behavior entirely different from that of the compounds of the heavy metals especially of Pb, Hg and Zn. The human body is indifferent to it and the use of Al utensils is absolutely harmless. EF (14a)

Rotors with Cast Conductors. E. C. Wadlow. *Electrical Review*, Vol. 116, Feb. 22, 1935, pages 265-266. Deals with use of Al and its alloys for small squirrel-cage motors. These metals are the only ones which satisfactorily fulfil major requirements of cost, electrical conductivity, m.p., and ease of casting, when conductors are cast in position. Cross-sectional area with Al to give same resistance as Cu is about 1.62 as great. This increased area is usually obtained by elongating conductors radially. Al rotor will have smaller moment of inertia than one of Cu and will accelerate more quickly for similar torque-speed characteristics. M.p. is not so high as to give serious casting difficulty or so low as to cause trouble should motor overheat in service. Because of difficulty of obtaining sound pure Al castings, Al alloys merit consideration, although their electrical resistivities are invariably higher. Al-Si alloys are perhaps most suitable casting alloys available. Tests show that modification and heat treatment reduce resistivity appreciably. Motor with sand-cast 11% Si-Al rotor had better torque-speed characteristics than one with chill-cast rotor. Heat treatment of latter improved characteristics to nearly those of the sand-cast assembly. Metal molds are essential for quantity production. Gravity feed gives sounder castings than pressure feed. Rotor stampings should be preheated before casting. With a chill mold a temperature of 250°-300° C. may be required. MS (14a)

Cadmium-Base Bearing Metals. Alan S. Gill. *Proceedings of the Australasian Institute of Mining & Metallurgy*, No. 95, Sept. 30, 1934, pages 201-227. See *Metals & Alloys*, Vol. 6, Mar. 1935, page MA 126. AHE (14a)

A Novel and Interesting Application of Copper Tubes (Une nouvelle et intéressante Application des Tuyaux en Cuivre). A. Chaplet. *Cuivre et Laiton*, Vol. 8, Apr. 15, 1935, pages 161-163. Describes installations of Cu tubing for butane and propane gas in isolated installations. Ha (14a)

14b. Ferrous

M. GENSAMER, SECTION EDITOR

Bearing Tests with Cast Iron as Bearing Metal (Lagerlaufversuche mit Gusseisen als Lagermetall). W. MEBOLDT. *Zeitschrift Verein deutscher Ingenieure,* Vol. 79, May 25, 1935, pages 629-631. Tests are described to replace bronze bearings by cast Fe bearings. The standard cast Fe (German) type Ge 26.91 with 0.72% P (exact composition not given) was found superior to bronze as the load could be increased almost twice before wear began; for the same safety margin this would mean smaller bearings. The material was used with advantage in agricultural machines. Constructive details are discussed. 9 references. Ha (14b)

Forming, Welding, Finishing Blown-Up Steel Trademarks. H. B. LEWIS. *Steel,* Vol. 96, Mar. 18, 1935, page 46. Parts for a large eagle were cut and formed from steel sheets, gas welded into subassemblies, porcelain enameled, and assembled by means of sheet-metal drive screws. MS (14b)

All-Steel Gas Range. E. C. KREUTZBERG. *Steel,* Vol. 96, Mar. 25, 1935, pages 26-29; Apr. 8, 1935, pages 22-24. Describes design, construction, and fabrication of range developed by the Tinnerman Stove & Range Co., Cleveland, O. It has a welded steel angle frame, stainless steel trim, and Cr-plated steel tubular legs and handles, and is covered with porcelain enameled steel sheets. Only castings used are the burners, burner holders, and several accessory parts. MS (14b)

Gears for Marine Main and Auxiliary Drives. H. E. MERRITT. *Institute of Marine Engineers,* Vol. 46, Jan. 1935, pages 305-324. Paper presented to the Institute, Dec. 11, 1934. Deals with stress factors. Physical properties of 30 gear materials are tabulated. Gains are due to higher physical properties although some materials, notably the high tensile Ni-Cr steels, do not give the advantage their tensile strength might lead one to expect, because of pitting and abrasion. Kz (14b)

Outdoor Furniture of Steel—Fabricating and Finishing. B. K. PRICE. *Steel,* Vol. 96, Apr. 22, 1935, pages 24-27. Describes operations in manufacture of steel furniture by Bunting Glider Co. Use hot and cold rolled sheets, hot strip, hard angles, high-C spring steel, wire, and tubing. MS (14b)

Test of a Flat Steel-Plate Floor Under Loads. L. B. TUCKERMAN, A. H. STANG & W. R. OSGOOD. *Bureau of Standards Journal of Research,* Vol. 12, Mar. 1934, pages 363-377. In coöperation with the American Institute of Iron and Steel Construction, Inc., a flat steel-plate floor was tested under loads to determine its strength and whether the floor behaved as a unit when the loads were applied. The results are based on strain-gage and deflection readings. WAT (14b)

Crane Ropes, Chains and Hooks. A. TAYLOR. *Mechanical World & Engineering Record,* Vol. 97, Feb. 8, 1935, pages 129-130. **General Procedure for Inspection of Steelworks Cranes.** Mar. 1, 1935, pages 205-207, 214. Abstract of a paper "Lifting Equipment—Its Care, Inspection and Maintenance," presented to the Manchester Association of Engineers. Material used for chains is made by the puddling process from specially graded pig iron, comparatively low in S, P, and Si. Influence of temperature changes on the life of chains. Reasons for the necessity of annealing and normalizing chains periodically. 0.40 C steel is material used for forged hooks, shackles, and pins. Forging, heat treatment, machining, inspecting, and testing are dealt with. Discusses material and manufacture of laminated hooks. Crane lifting ropes are usually made from acid steel. Kz (14b)

Use of Steel in Shaft Sinking (Die Verwendung von Stahl zum Ausbau von Blind- und Hauptschächten). R. WÜRKER. *Glückauf,* Vol. 71, Mar. 9, 1935, pages 234-236. Advantages of steel, especially alloy structural steel, over wood in the construction of vertical and horizontal shafts are discussed, examples described and curves for compressive strength of different profiles given. Ha (14b)

Sheet Packages in Lacquer Industry (Die Blechemballagen in der Lackindustrie). *Farben Zeitung,* Vol. 40, Apr. 13, 1935, page 379. Lacquer industry represents one of the largest consumers of sheet packages. The utilization of black sheet cans and tin plate is critically discussed. Larger varnish plants produce their own tin plate. The density of the Sn-coat is checked by the "gelatine test." The samples are carefully cleaned with a soft rag and soap suds, rinsed and dipped into hot water. A warm solution of 1.5 pts. gelatine, 0.5 pts. glycerine, 0.2 pts. potassium-ferricyanide and 20 pts. of water are brought in contact with the sample for 10-24 hours. Dark spots indicate pores. Over-stretching during deep drawing can be detected with a paper soaked in the above solution. Recently tinned steel strip has become a strong competitior of ordinary tin plate. The greater strength of the former results in weight savings. EF (14b)

Steel Replaces Masonry For Lake Crib. *Iron Age,* Vol. 135, Apr. 25, 1935, page 28. Brief description of steel crib being constructed by Bureau of Engineering, city of Chicago. Total quantity of steel used is 1077 tons. Substructure 90 ft. in diam. and 40 ft. high. Unusual feature of interior is a stainless steel ring 39 ft. in diam. and 10 ft. high. Steel is 16 gage and totals 3700 lb. in wt. VSP (14b)

Woven Galvanized Wire Tape Shows Merit as Roadguard Material. *Steel,* Vol. 96, May 13, 1935, pages 34, 36. Developed by Page Steel & Wire Co., Monessen, Pa. Each strip of tape is made up of 21 independent 11 W. & M. gage hot galvanized wires, woven together and held by half-round steel clips spaced every 6 in. Gives results of impact tests with loaded automobiles. These proved to be satisfactory. MS (14b)

Large Uses of Steel in Small Ways. No. 286. Coal Windows. *Steel,* Vol. 96, May 13, 1935, page 38. Coal windows for residences, apartment houses, and public buildings provide a market for rolled steel and gray-Fe, semi-steel, and malleable castings. Floor-plates and Cu-bearing and galvanized steel sheets are used. MS (14b)

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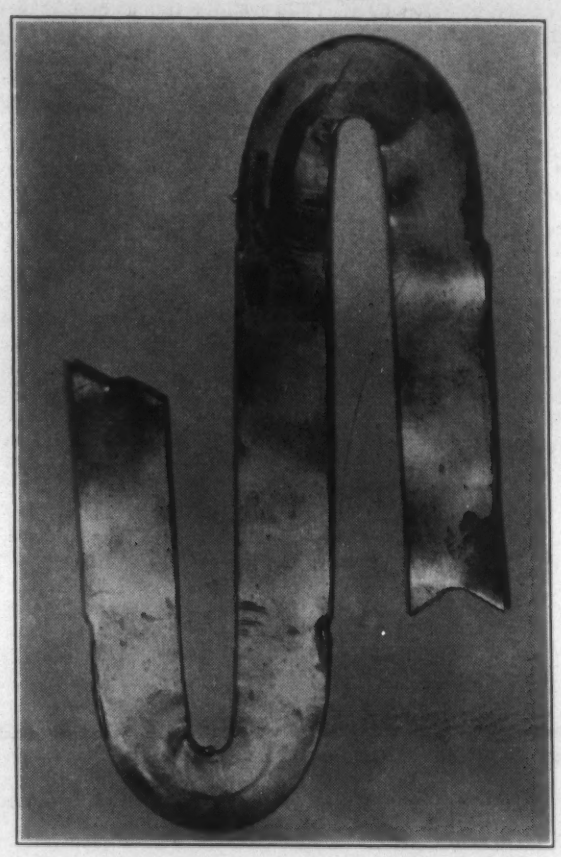

The illustration (unretouched) shows the results of cold edge-bending in reverse a strip of OFHC copper 0.056" thick. Note the absence of cracking or tearing at *either* of the outer edges.

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New Developments in the Field of Special Steels (Neuere Entwicklungen auf dem Gebiet der Sonderstähle). A. FRY. *Montanistische Rundschau,* (Section *Stahlbau-Technik*), Vol. 27, Apr. 16, 1935, pages 1-6. Abstract of a paper read in Essen in June, 1934, and published in full in *Technische Mitteilungen Krupp.* See *Metals & Alloys,* Vol. 6, Feb. 1935, page MA 80L/9. BHS (14b)

Steel Rule Dies for Folding Paper Boxes. ROBERT F. SALADE. *Iron Age,* Vol. 135, Feb. 21, 1935, pages 35, 84, 86. Describes the making of steel rule cutting and creasing dies used in manufacture of all styles of paper boxes. Considerable quantities of steel in various thicknesses and tempers are used annually. VSP (14b)

Crankshafts and Axleshafts of Steel of High Damping Capacity (Kurbel- und Übertragungswellen aus dämpfungsfähigem Stahl). O. FÖPPL. *Mitteilungen des Wöhler-Instituts,* No. 25, 1935, pages 62-72. A discussion of the desirability of using high damping capacity steel for shafts. The factor of safety should be based not only on the endurance limit and the permissible torsional deformation but also on the damping properties. If the shaft is so designed that the weakest place is in the cylindrical portion and not at keyways, splines or changes in section, the permissible torsional force is dependent upon the damping. If resonant vibration builds up high stress one must either use vibration dampers or use a material of high damping capacity. In a 700 HP Diesel engine, a 1700 lb. shaft can be called upon to absorb 13 HP as heat by damping. The ability of the design to dissipate this heat is important. By working the surface the endurance limit can be raised about 10% and this will enable one to increase the stress so that the damping can be increased 60%. Failure of the rear axle of an 8 cylinder auto by fatigue in the splined end was examined and ascribed to neglect to cold work the fillets of the splines, to improper fillets, and to the use of too strong a steel, one of 130-145,000 lbs./in.^{2} when one of 85,000 lbs./in.^{2} would have been more suitable, because of higher damping capacity. It is suggested that the diameter of the unsplined part of the shaft should have been so reduced that its loading would have been increased and the damping of the whole shaft thus improved. HWG (14b)

Making Measuring Cups from Stainless Bar Stock. ROGERS A. FISKE. *Iron Age,* Vol. 135, Mar. 7, 1935, pages 17-19. Describes the production of stainless steel measuring cups by the Liquid Carbonic Corpn., Chicago. Old method involved casting each cup separately of 27% "nickel silver" and only 85% of castings proved satisfactory. Cups are now made from 18-8 free turning stainless steel bars $2\frac{1}{16}$" in diam. and 8 ft. long in a $2\frac{3}{4}$" Cleveland automatic. Special attention must be given to tool lubrication. Tools used are made of Rex 95 high speed steel and spindle speed is 170 r.p.m. One of the most important items is the finish. Stainless steel cups are superior not only from standpoint of service in fruit acids but also from the viewpoint of wastage of labor and material. VSP (14b)

Nickelclad Steel (Nickelplattierter Stahl). R. W. MÜLLER. *Werkstoffe & Korrosion,* Vol. 10, Apr. 25, 1935, pages 20-21. Ni clad steel consists of a soft steel sheet which is coated usually on one side, sometimes on both, with a thin sheet of pure Ni; both metals are intimately joined by rolling Ni onto the steel at high temperature. Thicknesses of 5-25 mm. are produced of which Ni forms 10-20% of the total thickness. Sheets of a max. dimension of 12 m. length and 3.7 m. width have been produced with 12.5 mm. thickness. The steel has 0.20% C, 0.47% Mn, 0.018% P, 0.04% S. The mechanical properties for the steel alone and the Ni plated material are practically alike, namely:

	ultimate strength	elastic limit	elongation	red. of area
steel alone	42.0 kg./mm.^{2}	25.8 kg./mm.^{2}	27.5%	50.7%
Ni clad ..	42.5 kg./mm.^{2}	28.4 kg./mm.^{2}	30.0%	58.0%

The material is used particularly in cases where large dimensions and heavy stresses coincide, as in autoclaves, pressure tanks, vacuum vessels. Ha (14b)

Making Porcelain Kitchen Ware. J. B. NEALEY. *Iron Age,* Vol. 135, Apr. 25, 1935, pages 29-31, 92. Describes method and equipment used by the Strong Mfg. Co., Sebring, O. One important item, a pan 16 x 20 x 6 in. deep, is made from 20-gage steel. Operations required to complete the article are: Blank, draw, anneal, trim, bead, pickle and enamel. Gas fuel is used. VSP (14b)

Porcelain-Enameled Tile Made on a Mass Production Basis. F. L. PRENTISS. *Iron Age,* Vol. 135, May 9, 1935, pages 12-13, 94. Describes methods and equipment developed by the Youngstown Pressed Steel Co., Warren, O. for handling small enameled steel tiles on conveyor belt in continuous straight line production. Same equipment may be used for enameling other small flat objects. Tiles are made of 20-gage vitreous enameling sheet steel. VSP (14b)

Modern Cast Irons in Chemical Engineering. J. G. PEARCE. *Journal Society of Chemical Industry,* Vol. 53, Dec. 14, 1934, pages 1052-1058. Cast irons have been notably improved within the last 15 years as regards mechanical, physical, corrosion and heat-resistant properties. Remarkable improvement in structural soundness is attributed to better molding, melting and pouring technique. The most striking advance in the production of strong irons has come about by reduction of size and quantity of graphite. Addition of Ni and Cr is highly beneficial in improving physical and mechanical properties as well as resistance to many forms of corrosion and resistance to heat. Cr by itself as an alloying element appears to accelerate H_2SO_4 corrosion, while Cr with Ni and Cu affects high corrosion resistance. Several alloy cast irons are described, one containing 18% Ni, 6% Cr and 2% Ni; another containing 14% Ni, 6% Cr and 5% Cu. The C in both of these commercial alloy irons, available here and in Europe, varies between 1.8 and 3%. Ni-bearing austenitic irons offer great advantages in that they can be made extremely soft (Brinell 120-140), are easily machineable, take a high finish, are stronger and tougher than the common gray iron, and harden under cold working. These alloys are suitable for use against various strengths of H_2SO_4, NaOH or KOH. The best all around chemically resistant iron is the high silicon (12-16%) iron. This material is extraordinarily resistant to many organic and inorganic acids, alkalis and salts. It is extremely difficult, however, to machine and has limited application where pressure is involved, due to low impact value. The Si irons show negligible losses in boiling HNO_3 (20% and 90%) and in boiling H_2SO_4 (20% and 65%), and equally small losses in mixed acids. The article is amply supported by photomicrographs and tables of data. 20 references. AAA (14b)

An Important Outlet for Cast Iron: Road Paving (Un important débouché pour la Fonte: le Pavage des Routes). *Usine,* Vol. 44, Apr. 11, 1935, pages 17-19. Reports on results of paving street and highways in France with cast Fe blocks of 90-150 kg./m.^{2} weight. Substructure, roadbed and shape of blocks are described. 1 Ha (14b)

Remarks on Malleable Casting for the Benefit of Producer and Consumer (Einiges über den Werkstoff Temperguss zum Nutzen von Erzeugern und Verbrauchern). H. DITTMAR. *Giesserei,* Vol. 22, Apr. 26, 1935, pages 189-194. The usual composition of the pig iron from which white or black malleable iron is made is 2.6-3.6% C, 0.05-0.12% P, 0.14-0.5% Mn, 0.5-1.2% Si, 0.05-0.22% S. The exact composition is determined by the furnace used in malleableizing and whether white or black malleable Fe is to be made. C and Si are the determining factors for the malleableizing process, Mn and S, are less so, while P has no influence at all. Castings with very thick walls are preferably made of black malleable Fe; a number of curves show the physical properties of specimens of different dimensions. Attention is called to some discrepancies between actual tests and the values prescribed for white malleable Fe in the German D I N which latter are shown to be rather low. The question of black or white malleable casting is discussed but no definite rules for the selection of one or the other can be given. 2 Ha (14b)

Structural Sections in Levers of Truck Scales Improve Weighbeam Action. *Steel,* Vol. 96, May 20, 1935, page 33. Motor-truck scale produced by Gaston Scale Co., Beloit, Wis., has lever-frames made of ship channels and broad-flange beams, with I-beam struts spaced in the frames and welded in place. Knife-edges consist of a main section of cold-rolled steel and a working edge of high-C steel welded into a V-groove. Working edge is heat treated after welding. 3 MS (14b)

New Sound Screens of Steel Sheets. *Steel,* Vol. 96, May 20, 1935, page 38. Beckley Perforating Co., Garwood, N. J., has developed a sound screen for moving-picture theatres by providing 30-gage hot-rolled steel sheets with small louver perforations. They give superior reflected light, with no loss of picture, and set a new standard for sound reproduction. MS (14b)

Large Uses of Steel in Small Ways. No. 287. Shoe Trees. *Steel,* Vol. 96, May 27, 1935, page 56. Small tonnage of strip steel is used in manufacture of wood shoe trees. All-steel trees consume about 300 tons of cold-rolled strip. Wire is used for connecting toe and heel sections. Fabrication comprises chiefly stamping operations. 4 MS (14b)

Berger Steel-Frame House Project Initiated in Capital. *Steel,* Vol. 96, May 6, 1935, page 17. Describes house developed by Berger Mfg. Co., Canton, O. Built of prefabricated strip steel frame units and finished with any type of ordinary building material. MS (14b)

Composite Molding Formed by Drawing 18-8 Stainless Steel Over Wood Core. *Steel,* Vol. 96, May 6, 1935, page 37. Developed by Charles F. Biele & Sons Co., New York. Used for decorative trim in buildings, on furniture, and in many other applications. 5 MS (14b)

Rolled Steel Guard Rail for Bridges Is Mounted on Spring Supports. *Steel,* Vol. 96, May 6, 1935, pages 44, 46. Guard designed by Rex Road & Bridge Co., Pittsburgh, comprises rolled steel channels or formed sections supported on bent spring steel flats, which are bolted to bridge members. MS (14b)

The Use of Ferrous Metals for Aeronautical Purposes. J. R. HANDFORTH. *Metal Treatment,* Vol. 1, Spring 1935, pages 33-37. Present practice in the selection of steels for aero-engine construction is discussed, with particular reference to the relevant British Standard and Air Ministry specifications. Case hardening, constructional, spring, and alloy constructional steels are considered. 6 JCC (14b)

New Silicon Steel Commends Itself to the Electrical Industry. T. W. LIPPERT. *Iron Age,* Vol. 135, Feb. 21, 1935, pages 23-27. Discusses the properties of a new cold rolled low-Si electrical strip steel developed by N. P. Goss and Cold Metal Process Co. Its characteristics are similar to those of permalloy in high flux density ranges as well as in weak fields. Its permeability is very high throughout a broad range of magnetization, varying from weak fields up to saturation point of about 20,000 gausses. Hysteresis losses are low throughout this range. Includes graphs and tables giving results of tests. 7 VSP (14b)

High-Quality Steels for Structural Steel Work (Die hochwertigen Stähle für Stahlbauwerke). A. KROITZSCH. *Montanistische Rundschau* (Section *Stahlbau-Technik*) Vol. 27, May 16, 1935, pages 1-3. Gives specifications of Austrian government for special high-grade low-carbon steels St. 44 and St. 55, with instructions for milling and working. Table gives comparison of these steels with the German steel St. 52 and the British B. S. S. steel. Of interest is the use of a small amount of Cu in these steels, to increase the resistance to rusting. For the German steel the Cu content must not be less than 0.25% 8 BHS (14b)

Torsion Testing Machine of 750,000-in-lb. Capacity. BRUCE JOHNSTON. *Engineering News-Record,* Vol. 114, Feb. 28, 1935, page 310. Description of a torsion testing machine built at the Fritz Engineering Laboratory of Lehigh University. CBJ (14b)

Tool Steels and Hard Metals (Verktygsstaal och haardmetall). HANS KJERRMAN. *Teknisk Tidskrift,* Vol. 65, May 11, 1935, pages 194-204. Paper read before the annual meeting of the Swedish Engineering Societies. Discusses the different methods of determining hardness, one of the most important determinations for tool steels. Describes several types of furnaces used for heat treatment, including the A.S.A. (Swedish General Electric) continuous furnace. Several methods of hardening are discussed, such as the thermal method, the Shorter method, case hardening, and nitriding. Gives a review of the development of the high speed steels and the hard metals, stellite, tremonite steel and sintered W carbides. The hard metals are also available in cast form. Where very high abrasion is encountered, as in sand blast nozzles, the cast hard metals may outlast ordinary cast iron 400 times. 9 10 BHS (14b)

Sheets for Automobile Bodies (Die Karosserie aus Blech). H. KALPERS. *Die Umschau in Wissenschaft & Technik,* Vol. 39, Apr. 28, 1935, pages 347-350. The production of sheets and working processes in German automobile manufacture are described and illustrated. WH (14b)

Stainless Steel—Some Facts for the User. L. Sanderson. *Machinery*, London, Vol. 46, May 30, 1935, pages 263-264. Tubing of stainless steel is discussed as to bending, soldering, spinning, tensile properties. User of tubing should bend it cold and not more than a min. radius of 4 times the tube diam. For soldering a syrupy $ZnCl_2$ is suggested as flux after cleaning with 50% HCl and rinsing with water. Hot spinning is best practice and good results obtained with material over 12 gage. Cast 18-8 pipes are produced with min. wall thickness of 3/8". Cu in the 18-8 is advantage in improved resistance to H_2SO_4 and NH_4Cl and gives min. grain boundary attack after welding. Cu also improves ductility and reduces tendency to work harden. WB (14b)

Stainless in Aircraft. W. L. Sutton. *Aviation*, Vol. 34, June 1935, pages 30-32. The structural possibilities of electrically welded stainless steel are compared with the more familiar light alloys of Al. Stainless steel eliminates fear of corrosion and need of periodic inspection. Closed sections take higher compression stresses and are more resistant to accidental local damage. The relative allowable stresses for closed sections is 3.5 : 1 in favor of stainless steel and for open sections 3.0 : 1. The weight ratio (0.284 lbs./in.^{3} for stainless steel, 0.101 lbs./in.^{3} for Al alloys) is 2.81. The advantage obtained from properly designed stainless steel sections is shown. No anodizing or protective coating adds to cost of fabrication or maintenance. Shot welding lends itself with particular advantage to stainless steel and compares favorably in efficiency to Al alloy open sections. Shot welded stainless steel has one advantage not to be found in any other type of aircraft fabrication. It is very easy to secure a tension joint with 100% efficiency. Concerning the amount of local stiffness in the skin itself, Al is about 6.4 times as stiff as a stainless steel skin of equivalent weight. It is illustrated what can be done by proper design of stainless steel composite members which are assembled at low cost. Stainless steel tanks can be repaired by soft soldering. The available sizes and shapes of stainless steel and the comparative physical properties of both structural materials are fully discussed. EF (14b)

Alloy Cast Irons Win Place in Mining. B. H. Strom. *Engineering & Mining Journal*, Vol. 136, June 1935, pages 290-294. High strength hardness, and toughness, increased resistance to wear and abrasion, and to heat and corrosion characterize these materials. Various applications in the mining industry are indicated. WHB (14b)

Present-day Cast Iron and its Application Possibilities in Construction (Das heutige Gusseisen und seine Verwendungsmöglichkeiten in der Konstruktion). A. Thum. *Giesserei*, Vol. 22, May 10, 1935, pages 214-218. The great advances which have been made in improving the qualities of cast iron are discussed and the inherent differences in the behavior of steel and cast Fe as structural materials explained. While steel under plain tensile stress when tested in the usual bar form shows great elongation before fracture and an uniaxial stress, a steel bar with a notch shows a much reduced elongation and no elastic limit due to the stresses being now multiaxial. In cast Fe, the graphite veins in the structure exert a notch effect so that also here no elastic limit is observed and the stresses are multiaxial. The behavior of cast Fe under forced fracture and endurance (fatigue) fracture, the effect upon the latter by surface conditions, the influence of the casting skin, the great effect of shape are discussed exhaustively, and advantages of cast Fe, especially of thin walled castings, over steel castings of high strength are pointed out. The latter are more sensitive to stress disturbances in flow than cast Fe. 5 references. Ha (14b)

Practical Observations of Some High Carbon High Chromium Tool Steels. W. H. Wills. *Transactions American Society for Metals*, Vol. 23, June 1935, pages 469-494. Paper read and discussed at A. S. M. Convention, 1934. Previously abstracted from Preprint 29. See *Metals & Alloys*, Vol. 5, Nov. 1934, page MA 542. WLC (14b)

Airport Hangar Frame Built of Discarded T-Rails. F. N. Wildish. *Engineering News-Record*, Vol. 114, Apr. 4, 1935, pages 490-491. Description of an airport hangar built from discarded materials. Design features and construction methods are outlined. CBJ (14b)

Iron and Its Alloys in Structural Materials (Järnet och dess legeringar i byggnadsmaterial). R. Wijkander. *Teknisk Tidskrift*, Vol. 65, May 11, 1935, pages 175-182; discussion, pages 182-185. Paper read before the annual meeting of the Swedish Engineering Societies. Deals with the use of rolled steel in building construction and in bridge and ship building, giving special attention to the three types of steel, St. 37, St. 44, and St. 52. The latter is now used quite extensively in Sweden. Typical examples of some German St. 52 steels are as follows:

	C	Si	Mn	Cu	Mo	Cr
Cr-Cu	0.10-0.20%	0.40%	0.80%	0.60%		0.30%
Mo-Cu	0.10-0.20%	0.65%	max. 1.30%	0.40%	max. 0.30%	
Mn-Cu	0.10-0.20%	0.50%	max. 1.50%	0.70%		
Mn-Si-Cu	0.10-0.20%	0.80%	0.90%	0.50%		

Ni-alloy steel as well as steel with higher Cr content has also been used. Usually both Ni and Mo are avoided on account of their high price, and Mn, Si, Cr, and Cu are used in their stead. All the steels in the above table have about the same corrosion resistance. The author discusses testing methods and specifications, physical properties and analyses, corrosion resistance, and welding methods. The most promising method of combating rusting in cases where the high cost prohibits the use of the more expensive stainless steels is to use steel containing about 0.3% Cu, which has about 50% higher corrosion resistance than the common carbon steels. A higher Cu content may have an adverse effect on the strength of the steel. BHS (14b)

Economical Selection of Sucker Rods. Blaine B. Wescott & C. Norman Bowers. *Metals Technology*, June 1935, 13 pages, *Transactions American Institute Mining & Metallurgical Engineers*, Vol. 114, 1935. Although there are many different types of steels and irons used for sucker rods not over 4 types are required. The type of rod for a particular well depends on the corrosive conditions encountered and on the stress that the rods will be under. The sulphide wells are the most corrosive. Specific alloys for different services are recommended. The materials vary from high-strength alloy steels for the non-corrosive wells to wrought irons for the corrosive wells. JLG (14b)

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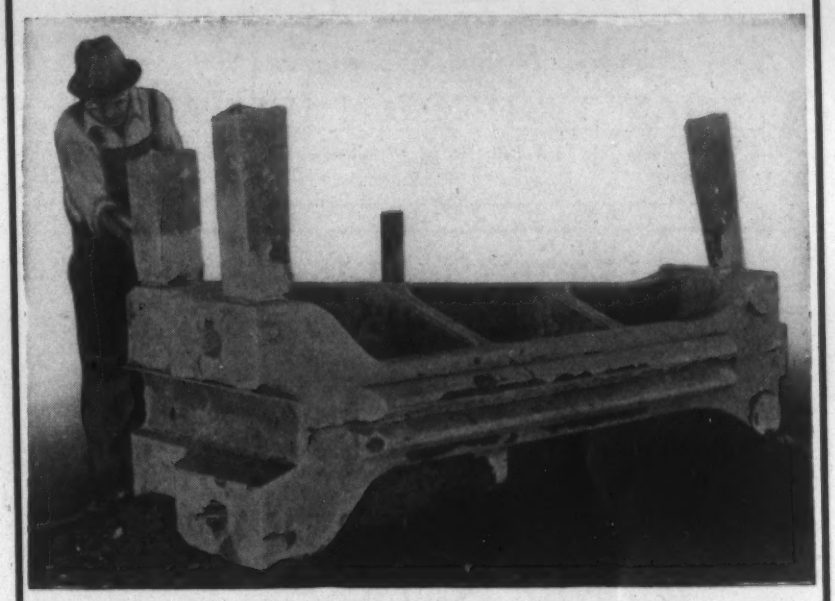

Recent Developments in the Field of Special Steels (Einige neuere Entwicklungen auf dem Gebiete der Sonderstahle). A. Fry. *Werft, Reederei & Hafen*, Vol. 16, Feb. 15, 1935, pages 63-65. See *Metals & Alloys*, Vol. 6, Feb. 1935, page MA 80L/9. WH (14b)

Metal for Housing, Stainless Steels and Enameled Iron. M. J. R. Morris & Karl Kautz. *Metal Progress*, Vol. 27, June 1935, pages 56-58, 78. **Advantages of Stainless Steel and Vitreous Enameled Iron in Architecture.** *Iron Age*, Vol. 135, June 6, 1935, page 54. Describes use of stainless steels and enameled Fe in domestic construction showing erection labor savings, greater permanence and desirable architectural results. WLC + VSP (14b)

Recommendations in Respect of the Use of High Tensile Steel for Structural Purposes. Appendix II to the Report on Steel Work for Buildings, Part I, Loads and Stresses. *Structural Engineer*, Vol. 13, May 1935, pages 246-248. These recommendations embody the views of the Institute of Structural Engineers on the use in structural work of steel as specified in British Standard Specification No. 548. They are based on investigations carried out by the Institution. With the exception of some cases specified, the working stresses for high tensile steel shall not exceed by more than 50% the stresses for mild steel allowed in the Institution's regulations. WH (14b)

All-Welded Steel Ocean Pier of Tubular and H-Piles. R. C. Helen. *Engineering News-Record*, Vol. 114, Jan. 10, 1935, pages 38-39. Steel trestle pier on ledge bottom resists severe wave action by welded connections. Steel piles are driven into the rock. Over 5 miles of welding required 27,150 lbs. of welding rod. CBJ (14b)

Structural Steel for the Machinery Industry (Konstruktionsstaal for maskinindustrien). Sven von Hofsten. *Teknisk Tidskrift*, Vol. 65, May 11, 1935, pages 184-193; discussion, pages 193-194. Paper read before the annual meeting of the Swedish Engineering Societies. High tensile and impact strength, resistance to fatigue and creep, to corrosion and high temperatures, good machinability, and freedom from inclusions and segregations are among the important specifications for these steels. Discusses physical properties of different types of steels, such as low C steel, low-alloy steel, case hardened and nitrided steels, and rustless steels. Emphasizes the desirability of cooperation between consumers and producers to reduce the large number of steel qualities to a few standard brands, thereby removing much of the present confusion. BHS (14b)

Welded Coal Wagons for the London and North Eastern Railway. *Engineering*, Vol. 139, June 7, 1935, page 609. Welding is advantageous for this purpose as it is possible to make a close connection between the floor plating and underframe which produces a rigid construction. This also prevents water from seeping through the flooring to the underframe below, thus lessening the corrosion of those parts. LFM (14b)

Maintain Open Attitude in Selecting Materials. H. F. Allen. *Machine Design*, Vol. 7, June 1935, pages 24-26. Design and selection of materials (mostly ferrous castings) used in the construction of a power shovel are discussed in full detail. WH (14b)

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15. GENERAL

RICHARD RIMBACH, SECTION EDITOR

The Life of Metal (La Vie du Métal). L. GUILLET. *Cuivre et Laiton*, Vol. 8, Apr. 30, 1935, pages 185-186. A somewhat poetical description of the life of a metal from its birth in the melting process through the manufacturing and heat-treating processes to final use, its maladies by impurities and improper treatment. Ha (15)

The Engineer and the Metallurgist. A. J. GRANT. *Engineering*, Vol. 139, Feb. 1, 1935, page 125. Brief abstract of presidential address delivered before the Sheffield Society of Engineers and Metallurgists, on Jan. 21. States that engineering progress depends largely on collaboration between the engineer and the metallurgist, and that great possibilities would be opened up as a result of further systematic research in metallurgy. VSP (15)

15a. Economic

Iron Ore Industry in 1934—Advance Summary. H. W. DAVIS. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 341, Jan. 11, 1935, 3 pages. Fe ore mined in the U. S. in 1934 was about 24,889,000 tons, an increase of 42% over 1933; shipments were slightly more. About 85% of shipments came from the Lake Superior district. AHE (15a)

Ferro-Alloy Possibilities of the South. EDWIN C. ECKEL. *Iron Age*, Vol. 135, Feb. 21, 1935, pages 32-34. Summarizes the southern situation with regard to native raw material supplies for the different ferro-alloys and related steels from T. V. A. point of view. Takes up Fe ores, low-grade Cr ores, Mn, Ni and Ti. Author believes that factor to be taken into consideration is the new supply of cheap electric power which cannot in itself produce a sound industry but that major part of the use will be in electrometallurgical and electrochemical operations. VSP (15a)

Gold, Silver, Copper, Lead and Zinc in Idaho. C. N. GERRY & T. H. MILLER. *United States Bureau of Mines, Statistical Appendix to Minerals Yearbook*, 1934, pages 93-120. Final figures are given for 1933. AHE (15a)

Copper Industry in 1934—Advance Summary. H. M. MEYER. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 343, Jan. 11, 1935, 3 pages. Smelter production from domestic ores increased 6% to about 476,000,000 lbs. Refinery production from domestic ores was about 462,600,000 lbs., a decrease of 18,700,000 lbs.; from foreign ores it increased 67% to make total refinery output 897,600,000 lbs., a 21% increase. Production of secondary Cu by primary refineries increased from 171,038,292 to about 248,000,000 lbs. Imports of unmanufactured Cu increased almost 60%, exports doubled, stocks declined about 23%. AHE (15a)

Is the Technique of Iron and Steel Making Laggard? Let's Look at the Record. JOSEPH F. SHADGEN. *Iron Age*, Vol. 135, May 2, 1935, pages 26-29, 104, 106. A reply to recent charges that the Fe and steel industry is backward in the development of processes and equipment. Author concludes that revolutionary changes are unlikely, but accumulated obsolescence due to economic conditions of past few years will stimulate improvement and refinement of established methods. VSP (15a)

The Iron Year 1933 (Das Eisenjahr 1933). *Metallbörse*, Vol. 24, Feb. 7, 1934, pages 164-165; Feb. 10, 1934, page 180; Feb. 14, 1934, pages 196-197. Eight tables show the production of Fe and semi-finished products of the 6 most important producers on the world's market during the last 4 years and 2 tables show the individual share of each nation during the last 3 years with reference to pig Fe and steel. The upward trend during 1933 and the advance of Russia are stressed. EF (15a)

Tin in 1934. *Tin*, Mar. 1935, pages 19-20. World production of tin in 1934 was 108,194 tons compared to 84,963 tons in 1933 and 92,908 tons in 1932. Only Siam showed a decrease in production. Although the apparent or import consumption of the United States showed a decrease of 25.8% over 1933, the actual consumption was but 12.2% less. Tin used in bearing metals in the U. S. increased by 10.9%, that in solder by 21.8%. A decrease in tinplate production accounts for the lower tin consumption. BWG (15a)

Tin Control or Chaos. *Tin*, Mar. 1935, pages 6-7. Tin production capacity is so much greater than present consumption that some control is essential. The plan thus far has rehabilitated the tin industry, stopped wasting of assets and given consumers an adequate metal supply at a reasonable price. BWG (15a)

Manganese Ore Industry in 1934—Advance Summary. H. W. DAVIS. *United States Bureau of Mines, Mineral Market Reports* No. M. M. S. 342, Jan. 11, 1935, 1 page. Shipment of Mn ores containing more than 35% Mn from domestic mines were approximately 26,000 tons (17,100 tons metallurgical) in 1934, an increase of about 7,500 tons over 1933. Montana, Arkansas, and Georgia supplied 90% of the ore. Shipments of ore containing 10-35% Mn increased 35% to about 17,000 tons, and of 5-10% ore, 198,000 tons, 11% increase. AHE (15a)

15b. Historical

Magnet Steels (Magnetstaal). *Polytechnisch Weekblad*, Vol. 28, Sept. 6, 1934, page 570. Historical review of recent developments in the fields of magnet steels (analyses given) emphasizing the contributions of Honda, Sumitomo, Köster and Mishima. WH (15b)

The Feistritz Iron Works and Wire Mill at Rosental (Das Eisen- und Drahtwerk Feistritz im Rosental). LUDWIG JAHNE. *Montanistische Rundschau*, Vol. 27, Apr. 1, 1935, pages 1-6. A historical review of an Austrian metallurgical plant dating back to the early part of the 16th century. Gives detail of old blast furnace and forging operations of Lancashire hearths and production of puddle iron. A rolling mill and a wire mill were built in 1840. Plant was in operation until 1930, when economic difficulties forced it to close down. BHS (15b)

Heat and Corrosion Resistant Alloys

Bulletin Cl-A illustrates a number of complex castings made from Q-Alloys which are recommended for pipe fittings, furnace parts, etc. General Alloys Co., South Boston, Mass. (A 491)

Phosphor Bronze

Booklet giving full information regarding this alloy which is a true bronze of copper and tin with the addition of phosphorus, and, in the case of bearing metal, of lead as an anti-friction ingredient. The Phosphor-Bronze Smelting Co., 2200 Washington Ave., Philadelphia, Pa. (A 492)

Alumite Plast-O-Fractory

Bulletin 26, Series A, contains directions for using and recommended applications for this refractory material in plastic, moldable form. Illustrated. The Massillon Refractories Co., Massillon, Ohio. (A 493)

P.D.M. Direct Fired Air Heaters

Bulletin 535 is devoted to the above which, the manufacturer claims, are applicable to almost all types of ovens, furnaces, dryers and dry rooms where they effect savings and permit higher temperatures than do indirect heaters. Philadelphia Drying Machinery Co., Industrial Furnace Div., 3351 Stokley St., Philadelphia, Pa. (A 494)

Steam Drop Hammers

Bulletin 255 discusses the Chambersburg Model E Steam Drop Hammers. The advantages of these hammers, whose cylinders are made of Cecolloy, are listed. Chambersburg Engineering Co., Chambersburg, Penn. (A 495)

Polishing Machines

A portable model and a floor model of these new metallographic machines are described and illustrated in a pamphlet from Eberbach & Son Co., Inc., Ann Arbor, Mich.

Published by the same firm: "Electrolytic Machine" designed on the Unit Power-Contained System for effecting electrolytic deposits. (A 496)

Aerocase

Booklet on this subject. Illustrations, curve charts, tables. American Cyanamid and Chemical Corp., 30 Rockefeller Plaza, New York, N. Y. (A 497)

Barrett Fusion Furnace

This furnace which was designed especially for coal ash fusions, and other high temperature work up to 3000 deg. F. is described and illustrated in a bulletin of the Burrell Technical Supply Co., 1936 Fifth Ave., Pittsburgh, Pa. (A 498)

Gases for Controlled Atmosphere Furnaces

A bulletin which discusses the advantages offered by liquefied petroleum gases, the two in principal use being propane and butane, has been issued by The Philgas Dept. of Phillips Petroleum Co., General Motors Bldg., Detroit, Mich. (A 499)

"Nothing is Impossible to Industry"

Leaflet descriptive of complete units for oil or gas using special composition cast pots. The Campbell-Hausfeld Co., Harrison, O. (A 500)

Spencer Turbo-Compressors

This bulletin which has illustrations of the complete range of sizes of this equipment also contains these new items: "Midget" Turbo for individual mounting, a single-stage line which effects new economies and Gas-Tight Turbos for acid and explosive gases. Spencer-Turbine Company, Hartford, Conn. (A 501)

Copperoid Steel Sheets

Leaflet illustrating and describing subject indicated. The Youngstown Sheet & Tube Co., Youngstown, O. (A 502)

Dolomite Refractories

This interesting pamphlet presents the case of Clinkered vs. Calcined Dolomite in the basic open-hearth steel furnace. Basic Dolomite, Inc., Hanna Bldg., Cleveland, O. (A 503)

Elfur Electric Furnace Iron Alloys

Bulletin setting forth data on Ni-Resist corrosion and heat resistant alloys particularly suited for locomotive wearing parts, Diesel engine parts, etc. Illustrated. Cramp Brass and Iron Foundries Co., Philadelphia, Pa. (A 504)

Properties of OFHC Copper

An attractive booklet contains reprints of three papers relating to the above subject. Photographs, diagrams and photomicrographs are used to illustrate them. United States Metals Refining Co., 420 Lexington Ave., New York, N. Y. (A 505)

Sonittep Products

A convenient looseleaf folder contains interesting facts on these products. Working data and applications of these products are given. Illustrated. George F. Pettinos, Inc., 1206 Locust St., Philadelphia, Pa. (A 506)

Industrial Furnaces

This catalog describes, illustrates and gives specifications for furnaces suitable for various applications. Mahr Manufacturing Co., Second and 18th Ave. N., Minneapolis, Minn. (A 507)

Refractory Cement

A leaflet pictures the results of a test performed on five brands of refractory cement which were trowelled on a tile and fired at 2700 deg. F. Charles Taylor Sons Company, 710 Burns St., Cincinnati, O. (A 508)

Mallory Elkon

Looseleaf catalog containing engineering data with descriptions, illustrations and recommendations for the selection of electrical contacts for all types of service. P. R. Mallory & Co., Inc., Indianapolis, Ind. (A 509)

Vanadium in Steel Castings

Treatise by Jerome Strauss, reprinted from Transactions of the American Foundrymen's Association. Illustrated. Vanadium Corp. of America, 120 Broadway, New York, N. Y. (A 510)

Chapmanizing

Bulletin describing process for hardening low carbon steel, what it is and what it does. Illustrated. Chapman Valve Mfg. Co., Indian Orchard, Mass. (A 511)

Oil-Hardening Steel

A colorful leaflet contains information on Invaro, which is a non-shrinking, non-deforming, oil hardening steel. Firth-Sterling Steel Co., McKeesport, Pa. (A 512)

New Method Annealing

Pamphlet containing data on this method. Illustrated. Power curves, comparison of annealing costs, etc. The Bellis Heat Treating Co., Branford, Conn. (A 513)

Refractories

The manufacturers of Shamva Mullite claim it is a super-refractory because it has a definite high melting point, great resistance to sudden changes of temperature and other features. The Mullite Refractories Co., Seymour, Conn. (A 514)

Misco

Leaflet describing the above line of stainless heat resisting corrosion resisting alloys. Illustrated. Michigan Steel Casting Co., Detroit, Mich. (A 515)

Binocular Microscope

Bulletin No. 9 illustrates a number of new constructions in wide field instruments with special reference to an automatic multiple objective nosepiece. E. Leitz, Inc., New York, N. Y. (A 516)

Brazing Alloy

Bulletin No. 5 advocates the use of "Sil-Fos" for joining brass, bronze, nickel, nickel silver, extruding brass and bronze, Monel metal and other non-ferrous metals and alloy fusing above 1300 deg. F. Handy & Harman, New York, N. Y. (A 517)

Stiffness Tester

Bulletin E-10133 is a technical description of Smith Tabor Model "A" Precision Stiffness Tester, for the scientific measurement of stiffness and resiliency. Wilson Mechanical Instrument Co., Inc., New York, N. Y. (A 518)

Electric Furnaces

A pamphlet describes the "Certain Curtain" furnace which was developed for positive furnace atmosphere control. It is designed for heat treating at temperatures between 1850 and 2500 deg. F. C. I. Hayes, Inc., Providence, R. I. (A 519)

Stainless and Heat Resisting Electrodes

A colorful price list and data book containing complete descriptions of the company's products and also analyses of stainless and heat resisting alloys manufactured by other companies has been issued by Maurath, Inc., Cleveland, O. (A 520)

Stainless Steel Castings

An attractive booklet contains useful information on the subject. Typical analyses, characteristics and suggested uses are listed. Joseph T. Ryerson & Son, Inc., Chicago, Ill. (A 521)

Current News Items

Changes at Carnegie Institute

Beginning with this fall the department of metallurgy and the metals research laboratory of the Carnegie Institute of Technology, Pittsburgh, will be combined into one organization and Dr. Robert F. Mehl will serve as both head of the department and director of the metals research laboratory. Alexander L. Feild is coming to the institute as professor of process metallurgy. It is planned to develop this subject rather rapidly, especially considering its importance in the Pittsburgh district.

Dr. F. N. Rhines will be professor of non-ferrous metallography, while Dr. Vsevolod N. Krivobok will continue as professor of ferrous metallography. Dr. Max Gensamer will present two new courses on the curriculum, one a sophomore course in general metallurgy, and the other a senior course in plasticity in the forming of metals. Graduate courses will be given in alloyed steels by Dr. Krivobok, in process metallurgy by Professor Feild, in physical metallurgy by Dr. Mehl, in crystallography by Dr. Charles Barrett, and in petrography by Dr. Charles Fettke. It is expected that there will be a gradual increase in the number of graduate students.

A new type of course will be given to the seniors, entitled "Modern Metallurgical Practice." This will attempt to present to the student a general discussion of the conditions of work in the metallurgical industries. The course will be presented by a series of well-known local metallurgical engineers and executives.

Dr. Mehl, who is also a member of the editorial advisory board of METALS & ALLOYS, has been asked to give the Institute of Metals Division lecture of the A.I.M.E. in 1936.

Two industrial fellowships are now operative in the metals research laboratory at Carnegie! The Aluminum company fellowship operating last year, and a new one by the Molybdenum Corp. of America.

Richard Rimbach will supervise the metallurgical department in the night school next year and V. V. Kendall will give a course on "Corrosion of Metals," available to both day and night school students.

Dr. Partridge's New Position at Hall Laboratories, Inc.

J. M. Hopwood, president, Hagan Corp., Pittsburgh, has announced the appointment of Dr. Everett P. Partridge as director of research of Hall Laboratories, Inc. In this position, which he will assume on Sept. 1, Dr. Partridge will be associated with Dr. Ralph E. Hall, the managing director of Hall Laboratories and his staff, with the scientific and technical specialists of Hagan Corp., The Buromin Co., and Calgon, Inc., all of which are allied organizations, and also with the incumbents of the Industrial Fellowship on Calgonizing sustained by Calgon, Inc., at Mellon Institute of Industrial Research. Dr. Partridge has distinguished himself during the past ten years by his researches on boiler-water problems.

Handy and Harman Errect Plant in Canada

Handy & Harman, dealers, manufacturers and refiners of precious metals, are building a new plant in Toronto. It will be operated by Handy & Harman of Canada, Ltd., a subsidiary company and will be located at 141 John St. in Toronto. The new plant will be equipped to carry on all operations now performed at the main plant in Bridgeport. The principal business of the company is the melting, rolling, alloying and refining of gold and silver for the arts and industries. Most of the sterling silver used by American silverware manufacturers is produced by Handy & Harman. They also supply silver and gold anodes for plating, "Specially Refined" silver for alloying, silver for chemical uses and silver or alloys of silver for use in the electrical industry; silver and gold wire and special forms as well as karat gold in various compositions and colors including gold solders.

Rebecca Hall announces the opening of her office at 180 North Michigan Ave., Chicago. She specializes in technical publicity and press distribution.

McQuaid to Deliver Campbell Lecture

A pioneer metallurgist whose discoveries regarding grain size and its control have made his name one of the most familiar in the metal world, has been selected to present the Edward De Mille Campbell Lecture at the seventeenth National Metal Congress & Exposition in Chicago. Harry W. McQuaid of the Republic Steel Corp., has accepted the invitation to present this lecture at the annual meeting of the American Society for Metals on Wednesday, Oct. 2. Since its establishment in 1926, the Campbell Lecture has become one of the major events of the technical programs of every National Metal Congress, and the lecturers have been men who ranked high in the metal field. This year's lecturer is no exception. Probably no other one man has contributed more to the store of data on grain size and its control than Mr. McQuaid, who is co-originator of the McQuaid-Ehn grain size test.

Dr. Grossmann to Lecture at Metal Congress

Dr. Marcus A. Grossmann, director of research for Illinois Steel Co., will present a series of five daily lectures on "Heat Treatment of Steel," at the Seventeenth Annual National Metal Congress & Exposition to be held in Chicago the week of Sept. 30, according to announcement today by W. H. Eisenman, Managing Director of the Show and National Secretary of the American Society for Metals. "Dr. Grossmann has succeeded in reducing a very complex subject to its most simple terms," Mr. Eisenman said, adding that "These daily lectures, to be given each afternoon in the New International Amphitheatre, will be one of the outstanding features of the Congress."

Dr. Young to Lecture at Columbia

Dr. C. B. F. Young, technical director of the U. S. Research Corp., Long Island City, N. Y., and director of research at the Biolite Corp., New York, will give a course in practical chemistry and practical electroplating at Columbia University, New York City. The course will be divided into two semesters, both consisting of two 3-hr. sessions per week. In the opening semester, the first hour will be devoted to a study of the modern theories of applied chemistry. The remaining two hours will be spent in the laboratory, where the students will perform their own experiments. This course is designed to give the plant man a thorough knowledge of inorganic chemistry. In the closing semester, the first hour will be given over to a lecture concerning the application of modern theories of electrochemistry to electroplating. The balance of the period will be spent in laboratory, where the students will perform experiments on electroplating baths. All electroplaters, buffers and plant men are invited to take this course.

Dr. Young attended undergraduate school at Howard College, Birmingham, Ala. On receiving his B.S. degree in chemistry from the above institution he was appointed as an assistant in the department of chemistry, Columbia University. At the latter institution, he was head of the lecture demonstration department for two years. He resigned this position and was appointed assistant curator of the Chandler Chemical Museum. During this time he continued his studies in electrochemistry under Prof. Colin G. Fink. The degree of Master of Science was conferred upon him in 1932 by Columbia University, and in 1934 he attained the degree of Doctor of Philosophy at the same institution.

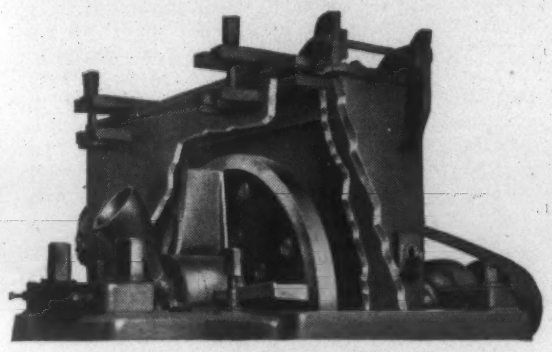
Alexander L. Feild, consulting engineer for the Rustless Iron Corp. of America and president of the Alloy Research Corp., Baltimore, Md., has been appointed professor of metallurgy at the **Carnegie Institute of Technology.** He will assume his new duties in September. Professor Feild brings to Tech a wealth of practical experience in the metallurgical industry as well as a thorough knowledge of the science of process metallurgy. He has successfully developed several processes for the melting and refining of steels, particularly alloy steels, which have become of great importance in the steel industry.

New Equipment and Materials

New Blast Cleaning Machine

Announcement has just been made by the Pangborn Corp., Hagerstown, Md., of a new blast cleaning machine adaptable to all types of work that entirely eliminates the need for compressed air as the abrasive driving agent. Instead, a rapidly spinning wheel securely journaled in the extra large ball bearings, propels the abrasive by controlled centrifugal force. It is this feature that gives the new unit its name of ROTO-BLAST.

The idea of using centrifugal force to replace compressed air in blast cleaning is not new. In 1870 a patent was granted Benjamin R. Tilghman of Philadelphia for a centrifugal sand blast machine. Since then a large number of other patents covering varia-



tions of centrifugal blasting have been issued. While the early centrifugal machines cleaned satisfactorily, their use was limited by what was regarded as excessive wear of parts made of the then available materials. Little was known about abrasive resisting materials of proper bearings and lubrication for the high speeds which centrifugal equipment demanded. So but slight success developed from the original patents.

Careful study and extensive tests have been made over a long period of time, experimenting with the new abrasive resisting metals and other high speed machinery requirements. The new "Rotoblast" is the result of this prolonged study. It is claimed that it is modern in design and stability, that it meets today's industrial demand for lower costs and improved blast cleaning production performances. It is so compact in design and adaptable in performance that it is recommended for use with barrel blasts, table blasts, special cabinets and similar equipment.

The Pangborn Corp. claims that the "Rotoblast" provides the lowest cleaning cost because of highest blasting efficiency and lowest maintenance. Loads of castings weighing 1,800 lb. have been thoroughly cleaned after 8 min. of blasting; 18 cu. ft. loads of grey iron, malleable and steel castings, forgings, stampings and heat-treated parts have been thoroughly cleaned in from 8 to 15 min. Low maintenance is assured because all parts exposed to blast action are of abrasive resisting material and of extra heavy construction.

Composite Type Part-Aluminum Dipper

By proper designing and the employment of aluminum alloy and high-tensile rolled steel for parts not subjected to the heaviest abrasion, the American Manganese Steel Co., Chicago, is producing composite type power-shovel dippers of unusually light weight. This new type dipper in the larger sizes can weigh less than half of the solid all-cast type, thus allowing a great increase in shovel capacity without a corresponding increase in power used.

A 15-cu. yd. AMSCO composite dipper recently shipped to the Commercial Fuel Co. for use on its Marion 5320 shovel in stripping coal replaces a 12-yd. solid dipper, and the 3 yd. added capacity is completely offset by the lighter proportional weight of the new bucket. This composite dipper weighs 32,940 lb. as compared with 74,000 lb., the weight of a 15-yd. all-manganese steel dipper made several years ago.

Dippers of this composite design have a top casting of manganese steel, of complete double wall construction, with integral bases and bail connections. The bottom casting, likewise of manganese steel, is also double walled at the back where the dipper stick is connected. The front plates are high-tensile rolled steel welded with spacers to provide a double wall between top and bottom castings. The back plate is of rolled aluminum alloy while the back braces connecting top and bottom castings are cast aluminum alloy. The door is a one piece manganese steel casting with integral hinges (U. S. Patent 1,989,818).

The "Alnor" Horizontal Edgewise Pyrometer

The Illinois Testing Laboratories, Inc., 420 LaSalle St., Chicago, is offering the "Alnor" horizontal edgewise pyrometer with selector switch for either 8, 17, 18 or 25 circuits. It has been designed and is built expressly for service wherever a pyrometer of great accuracy and reliability is needed.

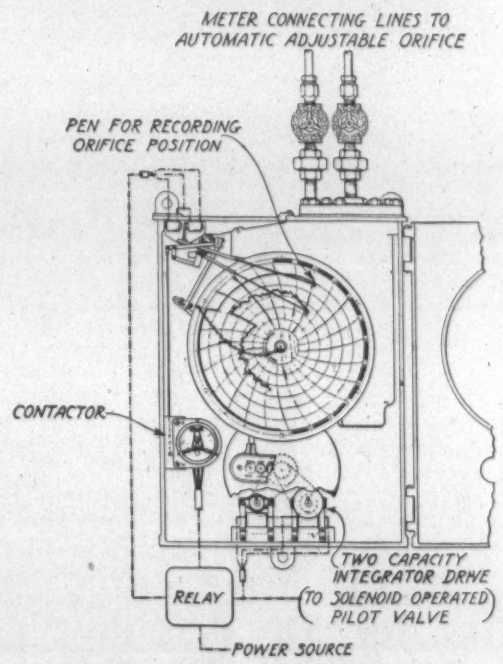
The indicator is ruggedly constructed so as to withstand severe vibrating conditions, jars and shocks, insuring long dependable performance. Perfect damping of the moving elements is assured. Simplicity of design, high

torque, high quality of material and careful workmanship are pointed to as providing permanence of accuracy. A special design of gasket structure for the indicator case excludes moisture, fumes and dust. A manually-operated cold end adjusting screw is provided. Internal resistance is exceptionally high. Dimensions of the pyrometer are: 7¼ in. wide, 10¼ in. high by 7 in. deep. In many different styles and sizes of "Alnor" thermocouples, there is a type suited for every equipment.

Adjustable Orifice Shifts Automatically

An adjustable orifice, which automatically shifts its position in accordance with major changes in rate of flow, is a new development of Bailey Meter Co., Cleveland. This device, when installed in a pipe line and connected to a standard recording and integrating fluid meter, is claimed to greatly widen the flow range which may be accurately covered by the meter.

The Bailey automatic adjustable orifice is similar in appearance to a hydraulically operated gate valve. The gate, however, is a sharp edged orifice segment, coefficients for which have been accurately determined. Its posi-



tion varies the size of the orifice opening through which the fluid measured must pass.

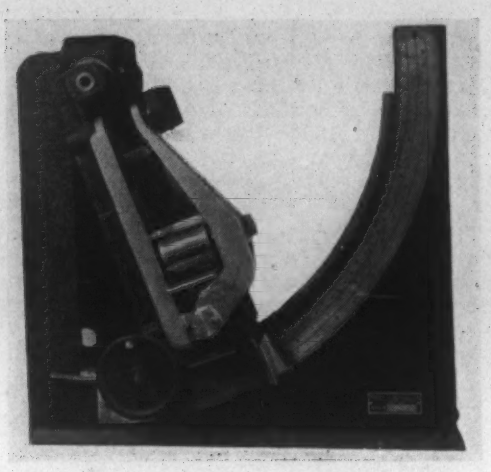
Movable stops limit the stroke of the hydraulic piston so that the orifice segment rests in either one of two definite positions. The piston which positions the orifice is actuated by a solenoid operated valve, which in turn is commanded by contacts made in the recording meter. Through the solenoid valve, hydraulic pressure is admitted to either end of the cylinder and the other end is opened to drain.

When the differential pressure across the adjustable orifice reaches a predetermined minimum or maximum, a contactor within the meter casing energizes the solenoid valve, automatically changing the orifice opening to correspond with a new capacity. Simultaneously with this change, the integrator drive is shifted to a second Warren motor so it continues to accurately measure the total flow regardless of the orifice position. In addition to changing the orifice position and integrator speed, the contactor also energizes a small solenoid which operates an auxiliary recording pen to show the proper multiplying factor to be applied to the corresponding flow record on the chart.

Under an increasing flow condition, the orifice shifts position at a higher rate of flow than it does under a decreasing flow condition. This overlap prevents constant shifting when conditions are such that the flow holds closely to the changeover point.

High Dry Sand Strength Tests

The Harry W. Dietert Co., Detroit, has recently placed on the market a high dry sand strength accessory for its type C.P. Universal Sand Strength Machine. In many foundries molding sand of exceedingly high dry strength is used, requiring a higher breaking load than is obtainable with sand strength testing equipment now available. The high dry strength accessory now affords a means of testing



the dry strength of molding sand mixtures which possess very high dry strength. The capacity of the type C.P. Universal Sand Strength Machine, equipped with the high dry strength accessory, as shown by this illustration, is 300 lb. per sq. in. dry compression and 220 lb. per sq. in. dry shear, which is sufficient to break sand specimen made from sand mixtures that possess exceedingly high dry strength.

The dry sand strength accessory may be quickly attached to the Universal Sand Strength Machine. Its simplicity and accuracy combine to make a most practical testing mechanism. The high dry sand strength accessory materially increases the usefulness of the Universal Sand Strength Machine.

Two New Ways of Obtaining a Wear-Resistant, Corrosion-Resistant Metallic Surface

After more than four years of developing and testing the application possibilities of heretofore unknown metallic boron crystals, Colmonoy, Inc., of Los Nietos, Cal., announces two new methods of economically preparing metallic surfaces against the ravages of wear and corrosion.

One method, known as "sweat-on," is to mix the metallic boron crystals with sodium silicate (water glass) to form a stiff paste; then cover the surface to be processed to the desired thickness (normally, from 1/16 to ⅛ in.) and apply sufficient heat from an oxy-acetylene torch, carbon arc or atomic hydrogen torch, to sink the crystals into the parent metal. This method produces a relatively level surface that is impregnated with diamond-hard, non-oxidizing, corrosion- resistant crystals, which retain their identity and do not fuse into a solid mass. After such processing, the parent metal is free to expand or contract, be formed or forged, without disturbing the wear-resistant, corrosion-resistant overlay.

The second method, advised for use where it is necessary to have a very smooth or ground and polished surface, is designated as the Colmonoy "cast-on" process. In this process, these same metallic boron crystals are held in a matrix of nickel alloy, which has a lower melting point than steel, (approximately 2000 deg. F.) facilitating easy melting and pouring to fill any desired space between a copper or cast-iron mold and the metal to be processed. This cast-on overlay fuses to the parent metal sufficiently to form 100 per cent bond, has a hardness of from 58 to 60 on the Rockwell "C" scale, and is not readily attacked by alkalis or acids. Its resistance to abrasion is quite phenomenal since the metallic boron crystals do not lose their identity in the alloy but remain firmly held in the alloy matrix to function in accordance with their remarkable properties.

New Air Operated Controllers

On its 75th anniversary, The Brown Instrument Co., Philadelphia, announces a new and complete line of recording and indicating air operated controllers for temperature, flow, pressure and liquid level.

The most outstanding of these is the Brown "Air-o-Line," a controller with 1 to 150 per cent throttling range and automatic reset. This control system recognizes and corrects for the magnitude, rate and direction of departure from the control point. These instruments are capable of full automatic control and will maintain a process at the control point within extremely close limits. Radically new is the simplicity of the means provided in the "Air-o-Line" for "tuning in" the controller to the specific process characteristics without interruption to automatic control. Throttling range and automatic reset dials are instantly adjustable with a screwdriver, without removing the chart plate. Indicating and recording thermometer-type temperature controllers are available for temperatures within limits of —40 and +1200 deg. F. Potentiometer-type controllers are available for temperatures within limits of —300 and +3400 deg. F.

Two types of flow controllers and liquid level controllers are also offered; the Inductance Bridge Type and the Mechanical Type. Thus, for the first time, the remote operating characteristics of the electric flow meter and the flexibility of air operated control are combined in one controller. Indicating and recording pressure controllers are available in ranges from 30-in. vacuum to 3000 lb. per sq. in. pressure.

In addition to the "Air-o-Line," three other types of Brown air operated controllers are included in the new line. These are, the Brown "Full Throttler," a controller with 1 to 150 per cent throttling range and manual reset; the Brown "Throttler," a controller with 1 to 10 per cent throttling range and manual reset; and the Brown "On-Off Controller," a controller for two-position service.

The simplicity and outstanding performance of this new line of Brown Air Operated Controllers, with their interchangeable control units and "ready-at-hand" adjustments, are pointed to as revolutionary contributions to the refining, chemical and other diversified industries.

Electric High-Speed Hardening Furnace

For some years the name of the Sentry Co., Foxboro, Mass., has been closely associated with quality hardening of high-speed steel, and many concerns benefit from the advantages offered by the Sentry diamond block method of producing the correct hardening atmosphere.

Now Sentry comes across with a brand new electric high-speed steel hardening furnace, a furnace that is so entirely different as to be in a class by itself, a furnace that has no water-cooling system to bother with or valves of any kind to adjust, a furnace that offers every advantage, quick heating, close temperature uniformity and control, arranged especially for Sentry diamond blocks and to take advantage of the fine quality hardening produced by this method—a furnace designed especially for quality high-speed steel hardening, possessing all the advantages of the larger and more expensive furnaces, and selling for the nominal price of $165.

X-Ray Inspection Made On Production Line

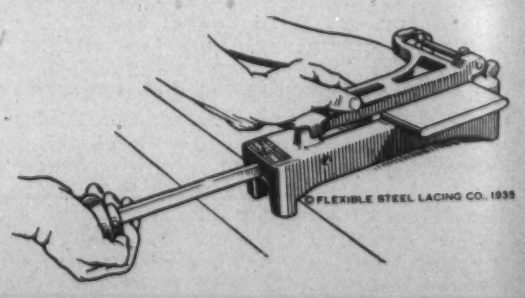
Manufacturers can now "see through" their products on the production line and detect flaws or stray pieces of foreign materials, according to an announcement by the Adrian X-Ray Mfg. Co., 3535 North Palmer St., Milwaukee, manufacturers of X-ray machines. As products pass through the machine on a conveyor belt, the operator looks through an eye piece to get an interior view of each unit. Any unit which does not come up to requirements can be marked for rejection by means of a pointer device. This is said to be the first time it has been possible to make an X-ray inspection fluoroscopically of goods in motion on the production line. The machine also has a radiograph attachment for making X-ray photographs, in case these are desired, o fany specific product.

Aluminum castings are examined for flaws in the metal, mica or bakelite is inspected for metal objects which might interfere with its efficiency as insulation, and so on. Fluoroscopic work has been done through ¼ in. of plate steel, and radiographing with 1 in. of steel. Although it has a voltage capacity of 150,000 volts, the unit requires only about the same amount of current necessary to operate two ordinary flat irons. Special tubes have been constructed and a cooling arrangement devised which permit continuous operation of the machine during working hours. No technical knowledge is required by the operator, who is in no way exposed to rays of the machine. The Adrian company has been building X-ray equipment of various types for 16 yr. Theodore F. Vogel is industrial sales manager.

Alligator Belt Cutter

An 8-in. flat belt cutting tool (U. S. Patent No. 1,992,600), which employs a new principle in mechanical belt cutting, is announced by the Flexible Steel Lacing Co., 4607-31 Lexington St., Chicago.

The cut is made by pushing the knife through the belt from one edge to the other. The knife is mounted on a plunger in a slot, as illustrated, and is operated easily by a direct arm push without mechanical leverage. The

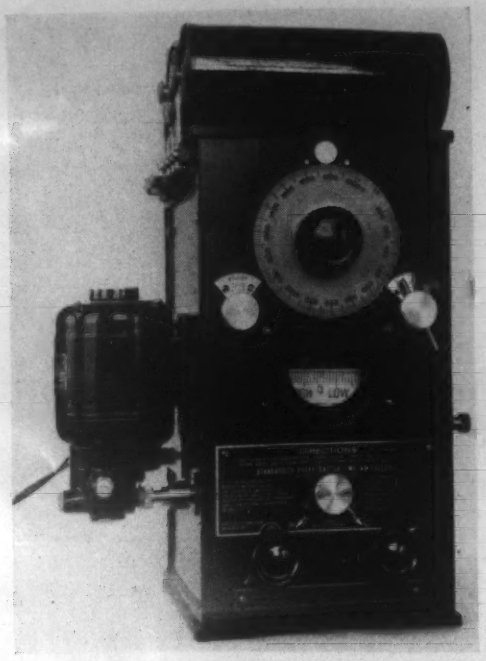


knife goes "like cutting cheese" through most belting, but it will cut even the thickest and toughest belts up to 8 in. in width with surprisingly little effort. The knife, of special alloy steel, will make several thousand cuts and is easily replaceable.

The belt is held immovable by the equalizing clamp or hold down while the cut is being made. The clamp is also a guard for the blade. Clamp and frame are strongly built of aluminum alloy, the weight of the cutter being only 4 lb. and 3 oz. The cutter is used either on the bench or is upended on the floor, if desired.

Improved Drive for Control Pyrometer

For installations where their potentiometer control pyrometers are to be used singly, The Foxboro Co., Foxboro, Mass., has developed an improved type of motor drive unit, called the "Type H." This drive comprises a ball bearing enclosed motor and a double worm



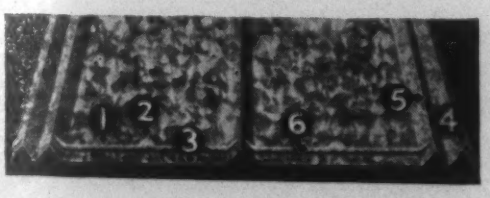
and gear speed reducing system packed in lubricant.

In addition to its availability for single-controller installations, this drive is amply powerful to operate one additional controller, through a coupling between the controllers. Although first quality construction is evident throughout the design and construction of this drive, it is offered at a considerable reduction in investment.

Globe Dri-Lap Roofing

A new galvanized 5V crimp sheet metal roofing, known as "GLOBE DRI-LAP," has been patented and introduced by the Globe Iron Roofing & Corrugating Co., Newport, Ky. The new roofing, according to the manufacturers, embodies distinct improvements:

Of first importance is the *air lock bead* (1), rolled horizontally across the sheet 1 in. up from the lower edge. This bead overcomes the force of capillary attraction by placing an air lock in the path of the water as it seeps upward between sheets at the laps. Water can rise no higher than the air lock bead.

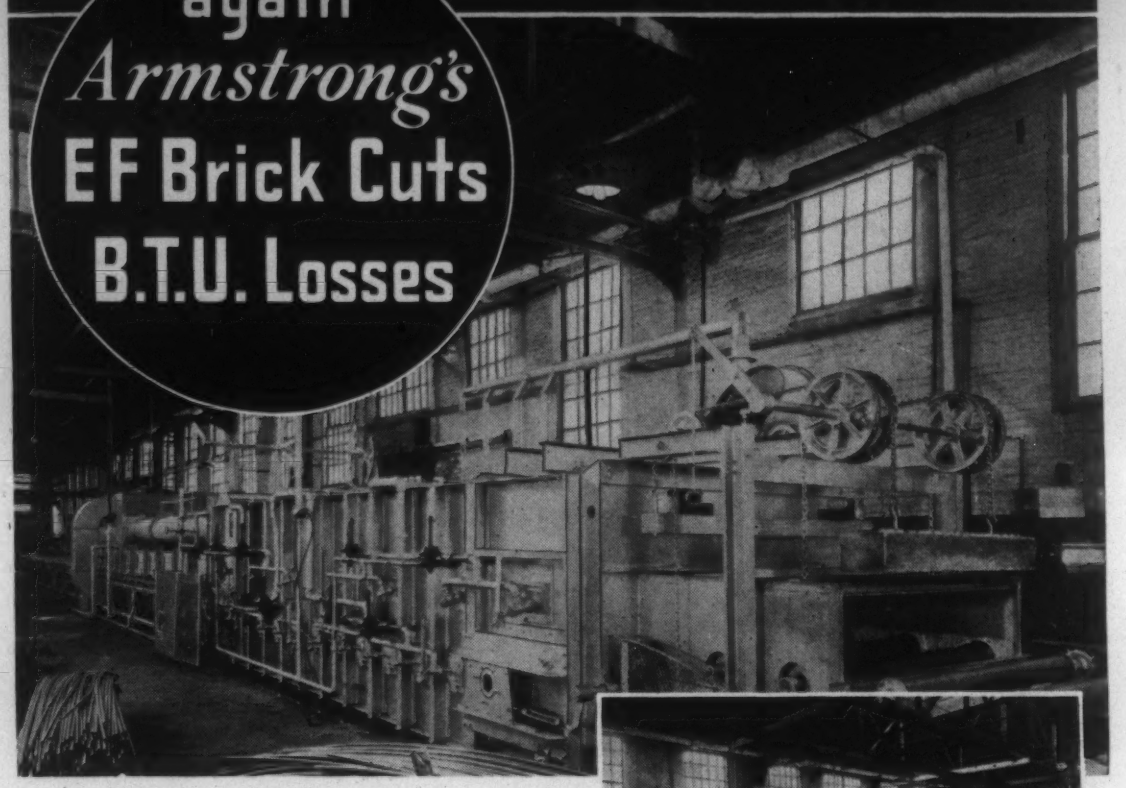


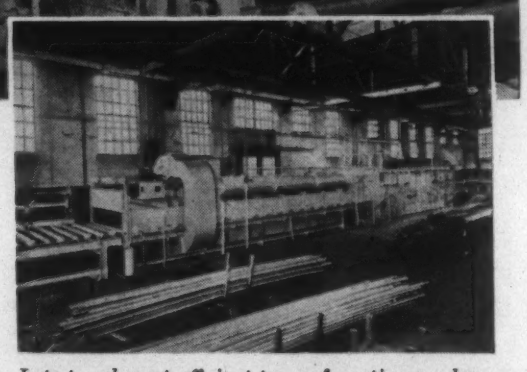
Rolled into the sheet in the center of the panel as an integral part of the air lock bead is a *nail seat* (2) which provides for additional nailing, eliminating unsightly openings at the laps and making a tighter roof. In the process of rolling the air lock bead, the lower edge of the sheet is bent down 1/16 in., making a *snug-fit edge* (3) which results in a tight contact between sheets at the laps. A continuation of the air lock bead is rolled into the outer crimps, forming the *self-aligning ridge* (4), which makes it possible to lay the roof in less time.

Since there is no change made in the crimps themselves (5), the new "Globe Dri-Lap Roofing" matches with any standard 5V crimp roofing, and the air lock bead adds another horizontal line across the courses (6), adding to the appearance of the finished roof. Globe Dri-Lap Roofing is available in all standard sizes.

Another efficient ROCKWELL furnace

again *Armstrong's* EF Brick Cuts B.T.U. Losses





Latest and most efficient type of continuous brass annealing furnace, built by W. S. Rockwell Co., is shown in the two views above. Uniform temperature is assured in this gas-fired furnace with walls of Armstrong's EF Insulating Fire Brick.

FOR more than forty-seven years, the W. S. Rockwell Co. has been designing and constructing modern industrial heating equipment . . . all sizes, for all purposes, using electricity, gas, oil, or coal. Naturally, such long experience has definitely proved to this company that proper insulating materials are required in building efficient furnaces.

In the construction of the gas-fired brass annealing furnace, shown above, Armstrong's EF Insulating Fire Brick were used, faced with Armstrong's Facing Cement and backed up with Armstrong's V-18 Block.

Use of Armstrong's EF Insulating Fire Brick insures accurate temperature control! And more! Since this light-weight semi-refractory brick requires no fire brick protection, it can be laid up in thinner walls. The result is less time required to bring the furnace to temperature, with a consequent fuel saving and speeding up of production.

For samples and data on EF Insulating Brick—and the other high temperature products in Armstrong's complete line—write to Armstrong Cork Products Company, Building Materials Division, 982 Concord Street, Lancaster, Pennsylvania.

High temperature products in Armstrong's complete insulation line include:

●

Armstrong's N-16 Insulating Brick for temperatures up to 1600° F. behind the refractory.

Armstrong's N-20 Insulating Brick for temperatures up to 2000° F. behind the refractory.

Armstrong's A-25 Insulating Brick for temperatures up to 2500° F. behind the refractory.

Armstrong's EF-22 Insulating Fire Brick. Light-weight semi-refractory brick for direct exposure up to 2200° F.

Armstrong's EF-26 Insulating Fire Brick for direct exposure up to 2600° F.

Armstrong's V-18 Block. Insulating block for use up to 1800° F.

Armstrong's

HIGH TEMPERATURE INSULATION

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